UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

APR 03 2000

4WD-SSMB

MEMORANDUM

SUBJECT: Monsanto Superfund Site
Augusta, Georgia

FROM: Mario E. Villamarzo, Chief
AL/GA/MS Section

THRU: Curt Fehn, Chief
South Site Management Branch

TO: Richard D. Green, Director
Waste Management Division

Attached please find a copy of the Five-Year Review Final Report for the Monsanto-Augusta Plant Site in Augusta, Richmond County, Georgia. Section 121 (c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended requires that if a remedial action is taken that results in any hazardous substances, pollutants, or contaminants remaining at a site, the Environmental Protection Agency (EPA) shall review such remedial action no less often than each five years after initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented.

The Record of Decision (ROD) for OU1 of the Monsanto-Augusta Plant Site was signed on December 7, 1990. The ROD required groundwater monitoring to evaluate compliance with the Groundwater Protection Achievement Levels (GPAL), and a pump and discharge to POTW system as a contingency remedy. Monsanto implemented the contingency remedy in May of 1992 after failing to comply with the GPAL. The extraction of groundwater will continue until compliance with the maximum contaminant level (MCL) for arsenic (.05 mg/L) is demonstrated for two consecutive years.

The attached Five-Year Review Final Report has gone through EPA Region 4 review. Based upon this review it has been determined that the remedial action taken at this site continues to be protective of human health and the environment. At this time we are seeking the Division Director's approval of this document.

Approved by: _____ Date 5 APR 00

Five-Year Review Report

Monsanto Corp. (Augusta, GA Plant)
1610 Marvin Griffin Road
P. O. Box 1473
Augusta, Georgia 30906-1473

Prepared for:
Environmental Protection Agency
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-3104

Prepared by:
HTRW Section
US Army Corps of Engineers
P. O. Box 889
Savannah, GA 31402-0889

EPA Five-Year Review Signature Cover

Key Review Information

Site Identification			
Site name: Monsanto Corp. (Augusta Plant)			EPA ID: GAD001700699
Region: IV	State: GA	City/County: Augusta, Richmond	
Site Status			
NPL status: Deleted			
Remediation status (under construction, operating, complete): Complete			
Multiple OU's* (highlight): Y Number of OU's: 2			
Construction completion date: 5/5/93			
Fund/PRP/Federal facility lead: PRP		Lead agency: EPA Region	
Has site been put into reuse? (highlight): N			
Review Status			
Who conducted the review (EPA Region, State, Federal agency): US Army Corps of Engineers			
Author name: C. W. Belin		Author title: Hydrologist, USACE, Savannah District	
Author affiliation: Engineering Division, US Army Corps of Engineers			
Review period: 6/29/99 - 7/31/99			Date(s) of site inspection: 6/20 - 30/99
Highlight: Statutory or **Policy**		Policy type (name) 1 Pre-SARA 2 Ongoing 3 Removal only 4 Regional Discretion	Review Number (1,2, etc.) 1
Triggering action event: First Five-Year Review Completion Date			
Trigger action date: 5/5/93		Due date: 7/31/99	

*** "OU" refers to operable unit.**

Deficiencies:

No general deficiencies were found

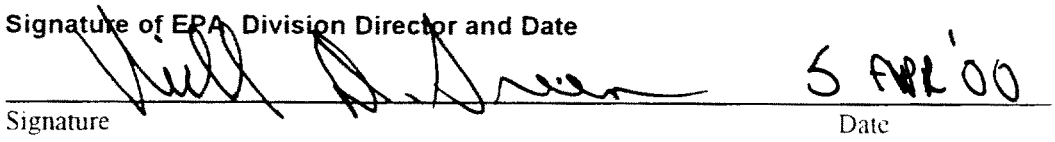
Recommendations and Required Actions: Continue with agreed regulatory action Replace the garden hose on MW-5 with a more permanent connection to the gravity drain, unless the well is shut down within one year.

Protectiveness Statements: Because the remedial actions at all operable units are protective, the remedy for this site is protective of human health and the environment.

Other Comments:

In order to better define the effect of the observed increase ground water pH and its potential to increase the concentration of arsenic in the ground water at the site, it is recommended to conduct a statistically-based data evaluation after another year of monitoring data is obtained.

Signature of EPA Division Director and Date



Signature

5 APR '00

Date

Monsanto Corp. (Augusta Plant)
First Five-Year Review Report

I. Introduction

The United States Environmental Protection Agency (EPA) Region 4 has conducted a five-year review of the remedial actions implemented at the Monsanto Corp. (Augusta Plant) site in Richmond County, Georgia. This review was conducted from June 1999 through July 1999. This report documents the results of that review. The purpose of the five-year review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify deficiencies found during the review, if any, and identify recommendations to address them.

EPA conducted this review pursuant the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), NCP section 300.430(f)(4)(ii) , because achievement of clean up levels will take more than 5 years at this site, a Five-year Review is conducted as a matter of policy. EPA conducts policy reviews when; 1) sites with pre-SARA RODs which, upon completion of the remedy, will not allow for unlimited use and unrestricted exposure, 2) long-term remedial action-sites where no hazardous substances will remain above levels that will allow unlimited use and unrestricted exposure upon completion of the remedy, but cleanup will require five or more years to attain, and 3) other sites which, upon completion of limited to, deleted sites with only pre-SARA RODs, sites with No Action or No Further Action RODs; National Priority List sites at which a State has selected a remedy under its own authority; and such other sites as the Region decides may warrant five-year reviews.

This is the first five-year review for the Monsanto Corp. (Augusta Plant) site. The trigger for this statutory review is the first 5-year review date shown in the EPA WasteLAN database 5/5/93. Hazardous substances, pollutants, or contaminants will not remain onsite, but more than five years are needed to complete remedial actions. All remedies have been constructed, and the ground water pump and treat system continues to operate as intended.

II Site Chronology

Table 1 lists the chronology of events for the Monsanto Corp. (Augusta Plant) site.

Table 1: Chronology of Site Events

Date	Event
1962	Monsanto built Landfill 1 for construction debris

Date	Event
1966 – 1971	Approximately 700 lbs. Arsenic placed in Landfill 1
1971	Landfill 1 closed
1971 – 1974	Approximately 800 lbs. Arsenic placed in Landfill 2
1974	Landfill 2 closed
11/01/79	Discovery
12/01/79	Preliminary Assessment
Aug 1983	Monsanto proposed to clean up landfills to GAEPD
Nov 1983	179 20-ton truckloads of material from landfills removed and disposed in Emelle, AL. Excavated sites backfilled and seeded.
1984	Site placed on National Priority List by EPA
8/16/89	RCRA permit approved aby GAEPD
9/14/90	Human Health Risk Assessment
12/7/90	Record of Decision issued
3/27 – 28/91	Monsanto and EPA sign Consent Decree and Modified Areas of Concern
10/8/91	Consent Decree with EPA entered into Federal Court Record
12/31/92	Removal Assessment
4/16/93	Remedial system started up (Extraction Wells EX2 and EX3)
5/5/93	Construction Completion Date
3/9/98	Deletion from NPL

III. Background:

The 75-acre Monsanto (now Solutia, Inc.) site is an industrial plant located three miles southeast of Augusta, Georgia. Land use in the area is predominantly industrial, with a wetland area located approximately 4,570 feet from the site. In addition, the site is approximately three miles from the Savannah River, an important source of water for the Augusta area. The plant began operations in 1962.

From 1966 to 1974, approximately 1500 pounds of arsenic trisulfide were placed in two onsite landfills encompassing approximately 0.1 acre each. The landfills were covered with soil, crowned with gravel, seeded with grass, and closed in 1971 and 1977, respectively. Ground water investigations conducted in 1979 and 1980 by Monsanto identified arsenic in the surficial aquifer in excess of the Federal maximum contaminant level (MCL). In 1983, Monsanto, through a State action, excavated the materials in the landfills and disposed of them offsite. Soil samples collected from the bottom of the excavated area did not exceed the EP toxicity standard for arsenic. Since the soil sample test results indicated that the arsenic level was below regulatory criteria, the excavations were backfilled. No formal landfill cap/cover was required. The backfill was mounded for drainage and the areas grass seeded.

This Record of Decision (ROD) addresses only ground water contamination. The primary contaminant of concern affecting the ground water is arsenic, a metal. The selected remedial action for this site includes monitoring ground water to evaluate compliance with Groundwater Protection Achievement Levels (GPALs); pumping and discharging ground water to an offsite publicly owned treatment works (POTW), in the event that non-compliance with GPALs occurs; ground water is to be monitored for 2 years following EPA's acceptance that the MCL has been attained.

The estimated present worth cost for this remedial action is $600,000.

PERFORMANCE STANDARDS OR GOALS: The chemical-specific and GPAL ground water cleanup goal for arsenic is 0.05 mg/L based on the Safe Drinking Water Act (SDWA) MCLs.

IV. Remedial Actions

A. Remedy Selection

The only record of decision (ROD) for the Monsanto Corp. site was signed on December 12, 1990. The remedial action objectives are to:

- Continue quarterly groundwater monitoring during design of the selected remedy to determine compliance with the Groundwater Protection Achievement Levels (GPALs);
- Should the annual average of the levels as determined by the quarterly monitoring exceed the GPALs, extraction of groundwater which exceeds the Primary Drinking Water Standard for arsenic will commence;
- Discharge extracted groundwater for treatment at a Publicly Owned Treatment Works (POTW); Groundwater monitoring for a minimum of two (2) years following the achievement of the Maximum Contaminant Level (MCL), in this case, for arsenic, 0.05 rng/L or 50 µg/L.

While there are technically two Operable Units (OUs) located at the Monsanto Corp site, designated 00 and 01 the former is used to designate the entire site, while the later functions to describe the two landfills.The remedial actions at OU1 are:

- groundwater extraction and discharge to POTW;
- quarterly monitoring of groundwater;
- surface water diversion and control; and
- institutional controls through fencing of the entire property.

B. Remedy Implementation

Several alternatives were fully evaluated for combating the arsenic contamination found at the Monsanto site. Of these, Alternative 3 (Pump and Discharge to a local sewage treatment facility) was found to achieve substantial risk reduction through treatment of the principal

threat due to the arsenic contaminated groundwater. During the design of the remedy, quarterly groundwater sampling was conducted. This alternative was selected because it was found to be protective of human health and the environment, would attain the ARARs, and would be cost effective and would utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Based on the above information and public comments, the US EPA, in consultation with the State of Georgia, approved the remedial design and the remedial action began on April 16, 1993.

On July 10, 1995, operation of the groundwater injection / extraction system at Landfill #1 began. Three months later, on October 20, 1995, the groundwater injection was discontinued and pumping continued from well MW5 and, later, at MW43. Pumping continues to date although on March 9, 1998, the site was officially removed from the National Priorities List via notice in the Federal Register, Volume 63, No. 45, pages 11375 through 11376. The remedy action is now included in the Solutia's Hazardous Waste Facility Permit issued under RCRA authority, and the facility will be subject to this corrective action requirements until cleanup of ground water contamination is complete.

Ground-water Extraction: Ground water is currently being pumped from five extraction wells. Three of the wells are located on-site and two of the wells are located at an industrial site just east of the Solutia site. One of the on-site wells is located at Area #1 and two wells are located at Area #2. All five extraction wells are screened in the surficial aquifer. Water from the wells is being pumped to the local POTW for treatment. The objective of the pump and treat system is to meet the Maximum Contaminant Level (MCL) for arsenic which is 0.05 mg/L. The shut-down criteria for the extraction system is outlined in the Record of Decision (ROD). The ROD states that in order for shut-down to occur, no monitoring or extraction well may exceed the cleanup criteria for arsenic for two consecutive quarterly readings for a period of two years.

Monitoring Wells: There are also numerous monitoring wells on the Solutia property and on the property where the off-site extraction wells are located. All of the monitoring wells are screened in the surficial aquifer. Many of the on-site monitoring wells were mistakenly placed up-gradient of the ground-water contamination during the investigation phase of the project. These wells continue to be monitored for arsenic contamination.

No unexpected site conditions have been discovered at the Monsanto facility during the remedial action, although minor problems occurred that were quickly and successfully corrected.

No formal landfill cover was placed over the excavated areas because the arsenic contamination was removed to below regulatory criteria,

C. System Operations

Work at the site has been funded by the Potentially Responsible Party (PRP), Monsanto Corp. (Augusta Plant), with oversight by not only the US EPA but also the GAEPD. Quarterly monitoring of the groundwater has been completed each year with both quarterly reports and annual reports being forwarded to the US EPA and GAEPD. In addition, daily inspections of the landfills and the pump systems have been accomplished by Solutia personnel. Periodic mowing of the vegetation growing on the landfill caps has been completed by Monsanto maintenance personnel. In addition, weekly inspections of caps, pumps, piping, and outfall 10 the POTW have been completed by Monsanto personnel.

D. Progress Since the Last Five-Year Review

Since this is the first 5-Year Review Report, no other report is available and thus no progress is reportable.

V. Five-Year Review Findings:

A. Five-Year Review Process

The site visit was lead by Ms. Glynda Harrington, ESH Leader for Solutia, Inc. The following team members participated during the site visit.

- Burt Taylor — Solutia Manufacturing Fellow
- Dale P. Voykin — Dames & Moore Senior Hydrologist
- Mr. Steve Butler — USACE, Civil Engineer
- Mr. Ric Hines — USACE, Civil Engineer
- Charles W. Belin. Jr., Ph.D. — USACE Hydrologist
- Franz Froelicher, Ph.D. — USACE Chemist
- Phillip E Smith, P. E. — USACE Civil Engine

The five-year review process began on June 1, 1990, with a visit by Dr. Belin to the Region 4 offices of the US EPA where he reviewed relevant documents pertaining to the project (See Attachment A). Copies of many of the documents were made and provided to the other USACE team members in order to allow them time to become familiar with the project prior to the site visit. Interviews of local personnel occurred during the time of the site visit. June 29 and 30, 1999.

B. Interviews

The only person who was interviewed concerning the two landfills and their monitoring was Mr. George C. Williams, one of the maintenance personnel at the Solutia Inc. facility. Mr. Williams has been an employee at the Solutia facility for several years and is familiar with the location of the landfills and what to look for when he makes his inspections. Mr. Williams checks the landfills each day he is on the job and searches for any erosion of the landfill

surfaces any undesirable vegetation on the landfills, and any other telltale slims of adverse impacts, including discolored or dead vegetation, dark patches of denuded soil, unusual odors, etc. Mr. Williams indicated that he has never seen any signs that the caps and landfills are not functioning properly. Mr. Williams inspects the ground-water extrusion system daily for proper operation and maintenance.

Mr. Voykin, senior hydrologist with Dames and Moore, Inc., Atlanta office, was interviewed regarding the implementation and operation and maintenance of the ground-water extraction system. He indicated that monitor wells are monitored for arsenic. While all wells are not included in this monitoring program, those that would afford the best perspective of the subsurface arsenic conditions are used.

C. Site Inspection

Initially the team met in the Solutia, Inc., office conference room to discuss the visit, the project, and the operation of the remedial action. Brief introductions were made by each team member. Then Dr. Belin started the meeting by describing the portions of the review, why the US Army Corps of Engineers was visiting the site. The team members were provided with the latest annual reports from the Solutia, Inc., contractor, Dames and Moore represented by Mr. Voykin. Following approximately 2 hours of discussion, we adjourned to the landfills and pumping area sites. We were given a thorough tour of the area by Ms. Harrington who explained the workings of the remedial action. In addition, Mr. Voykin was able to provide information concerning the technical aspects of the project. The landfill sites were visually inspected. No deficiencies were observed. The overall appearance of the landfills is shown on Images #1 and #5 in Attachment E of this report.

The site visit adjourned in late afternoon and resumed the following morning for additional questions and answers. At approximately 9:00, an exit briefing was provided to the Solutia Inc., personnel.

Ground-water Data: Mr. Dale Voykin of Dames and Moore provided a detailed summary of extraction system operations and sampling results. Mr. Voykin indicated that the surficial aquifer where the contaminated ground water is found is underlain by a clay aquitard approximately 40 feet in thickness. No contamination has ever been found in the lower aquifer. To date, over 25,000,000 gallons of ground water have been removed from the extraction wells. The wells are pumping at a very slow rate which is an indication of the low hydraulic conductivity of the surficial aquifer. No contamination has been found during recent rounds of testing at Area #1. Some of the wells near the Area #2 excavation and some of the off-site wells have exceeded regulatory criteria for arsenic during recent rounds of sampling.

The monitoring and extraction wells indicate that a plume of higher pH water is moving into the area of remediation from the southwest. During recent monitoring periods, the pH has been as high as 11 standard units on the southwest side of the remediation area. The source of the increase in pH is unknown. Solutia owns the tract of land immediately south of the Solutia plant site. This tract of land was purchased from a farmer and has never been the site of industrial activity. Solutia believes the source of the elevated pH ground-water plume is not on their property and has reported this situation to the State of Georgia. The state indicates they will investigate. Solutia fears the increase in pH may result in an increase to arsenic concentrations in the ground water which may lengthen the time required to achieve the clean-up goals.

Extraction Wells: All extraction wells appeared to be in good condition. Five wells are currently being used to extract ground water from the site:

Area # 1	MW-5
Area #2	MW-17 and MW-24S
Off-site	MW-42 and MW-44

All of these wells were originally installed as monitoring wells, however, they were converted to extraction wells to better contain the ground-water plume. MW-5 is connected to the gravity drainage piping with a garden hose assembly. Plastic disposal containers are used as protective covers over the extraction wells.

Area # 1: All wells in this area have met the clean-up goals for several sampling periods and Solutia is considering getting permission from the state to terminate pumping in Area #1.

Area #2 and Off-site Wells: Several wells have had exceedences for arsenic during recent sampling periods in these areas. Solutia believes these exceedences may be related to the increase in pH. More data are needed to confirm whether the rise in pH is causing an increase in the number of arsenic hits above the 0.05 mg/L regulator requirements.

Monitoring Wells: The monitoring wells appeared to be in good condition. Wells on the Solutia property are generally 4 to 6 inches in diameter. The off-site wells are flush mounted and are generally 2 inches in diameter. None of the monitoring or extraction wells have locking covers. However, all of the wells are protected from public access by security fencing.

All monitoring and extraction wells are sampled on a quarterly basis. Many of these wells are upgradient of the arsenic contamination. Therefore, the data are of limited value. Solutia has requested permission from the state to reduce the sampling frequency of four of these wells; MW-15, MW-31, MW-36, and MW-41.

Former Disposal Areas: The areas where the arsenic contamination was removed have been backfilled and mounded to promote drainage. An excellent vegetative cover is present at both Areas #1 and #2. Some equipment has been stored on top of Area #2, however, it will be removed soon.

D. Risk Information Review

The following applicable or relevant and appropriate requirements (ARARs) were reviewed for changes that could affect protectiveness of the selected remedy:

- Safe Drinking Water Act (40 CFR Parts 141 – 146);
- Resource Conservation and Recovery Act (40 CFR Part 264);
- Clean Water Act (40 CFR Parts 130 – 138);
- Clean Water Act (40 CFR Parts 231 – 232);
- Georgia Safe Drinking Water Act

No changes were discovered between the original ARARs cited in the Record of Decision and the current statutes and regulations applicable to the remedial action. This applied to both the chemical-specific ARARs and to the location-specific ARARs.

E. Data Review

A review of the historic data and the recent data of water samples analyzed from the Monsanto landfill wells showed that the pH has recently started to increase from pH 6 north to pH 11 south. The observed trend has taken place relatively recently and is shown by the latest round of sampling. As shown by Figure 6 (Attachment B), caustic conditions can cause the pollutant arsenic trisulfide presently physically bound to clay particles or other material in the soil to migrate as solubility increases. This increase in solubility becomes pronounced above a pH of 7.5 to 8. Arsenic trisulfide, insoluble in water or hydrochloric acid, dissolves only in alkaline solutions and in nitric acid. An unidentified offsite source of high pH appears to he located to the south of the Monsanto site. However, based on the information available, there are no compelling data that indicate an increasing ground-water arsenic concentration in response to increasing ground-water pH at the site. See Attachment D for data analysis.

Comparison of Initial and Current Groundwater Concentrations

Please see Table 1 at Attachment C

Treatment System Concentrations during February, 1999

Please see Table 2 at Attachment C

Groundwater Elevation Comparison

Please see Table 3 at Attachment C

A review of the Health and Safety Plan (HASP) and Contingency Plan indicates that both are in place and sufficient to control risks at the site.

In summary, the current remedial system is functioning toward meeting the cleanup levels for the contaminant of concern, arsenic. Monitoring data reveal that concentrations of arsenic are decreasing and will be below the MCL for both Federal and State of Georgia regulations within a few years.

VI. Assessment

The following conclusions support the determination that the remedy at the Monsanto Corp. (Augusta Plant) site remains protective of human health and the environment:

Question A: Have Conditions External to the Remedy Changed Since the Remedy Was Selected?

- ***No Changes in Land Use***: There are no current or planned changes in land use.

- ***No Changes in Known Contaminants, Sources, or Pathways at the Site***: No new contaminants, sources, or exposure pathways were identified as part of this five-year review. However, the pH of the groundwater is increasing slightly. An unknown offsite source of high pH is believed to be causing the increase in pH at the site. This may be a phenomenon of the pumping in effect pulling an alkalinity gradient towards the Monsanto site. Please refer to Section VIII. Recommendations.

- ***No Changes in Known Hydrologic/Hydrogeologic Conditions***: The rate of decrease of contaminant levels in groundwater is consistent with expectations at the time of the ROD.

Question B: Has the Remedy Been Implemented in Accordance With Decision Documents?

- ***HASP/Contingency Plan***: Both the HASP and the Contingency Plan are in place. Sufficient to control risks, and have been properly implemented.

- ***Access and Institutional Controls***: The site is fenced and patrolled frequently to ensure security at the landfills and the pumping areas.

- ***Remedy Performance***: In view of the fencing of the sites and the patrols, there is no deterioration of the landfill caps or the pumping areas.

- ***Adequacy of System Operation***: System operations procedures are consistent with requirements.

- ***No Need for Optimization***: In view of the results of the sampling regime, this five-year review does not identify a need for optimization.

- ***No Early Indicators of Potential Remedy Failure:*** No indicators of potential remedy failures were noted during the review process and the site visit.

Question C: Has Any Risk Information Changed Since the Remedy Was Selected?

- Changes in ARARs: None has been found

VII. Deficiencies:

No deficiencies were discovered during the five-review. The Review Team members believe the remedy is working both as designed and as expected.

VIII. Recommendations:

Table 9: Recommendations;

Recommendations	Party Responsible	Oversight Agency	Milestone Date	Required Actions: Currently Affects Protectiveness (Y/N)
Replace the garden hose on MW-5 with a more permanent connection to the gravity drain, unless the well is shut down within one year.	Solutia, Inc.	GAEPD	June, 2000	N
Conduct a statistically-based data evaluation after obtaining another year of data to determine if the increasing ground water pH could contribute to the increase of the concentration of arsenic in the ground water.	Solutia, Inc.	GAEPD	June, 2000	N

IX. Protectiveness Statements

Because the remedial actions at all operable units are protective, the remedy for this site is protective of human health and the environment.

X. Next Review:

Providing no changes are forthcoming with respect to sampling and analyses, the next five-year Review would be scheduled no later than July, 2004.

XI. Other Comments

We recommend the garden hose on MW-5 be replaced with a more permanent connection to the gravity drain, unless the well is shut down within one year.

Attachments

Attachment A: Documents Reviewed

Attachment B: Figures

Attachment C: Tables

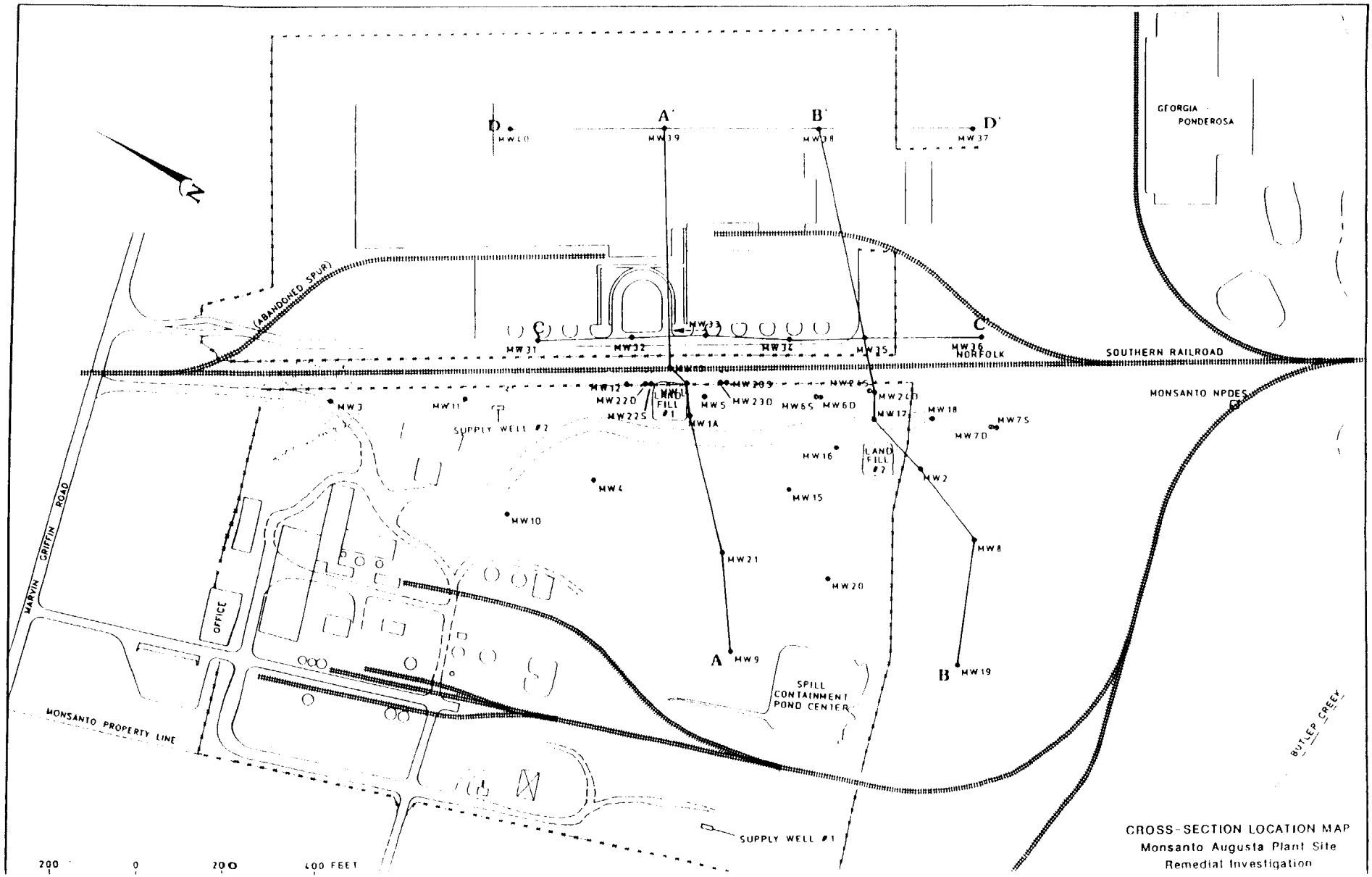
Attachment D: Data Analysis from William N. O'steen, EPA's Environmental Scientist, Memorandum dated November 29, 1999

Attachment E: Photos Documenting Site Conditions

Attachment A
Documents Reviewed

- Annual Report of Corrective Action Effectiveness. Solutia Inc. (Augusta) Plant Site. July 27, 1999. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Solutia Inc. (Augusta) Plant Site. July 1998. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Solutia Inc. (Augusta) Plant Site. July 1997. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Monsanto Corp. (Augusta) Plant Site. July 1996. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Monsanto Corp. (Augusta) Plant Site. July 1995. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Monsanto Corp. (Augusta) Plant Site. July 1994. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Monsanto Corp. (Augusta) Plant Site. July 1993. Dames & Moore, Atlanta, GA.
- Annual Report of Corrective Action Effectiveness. Monsanto Corp. (Augusta) Plant Site. July 1992. Dames & Moore, Atlanta, GA.
- Letter from Georgia Department of Natural Resources to US Environmental Protection Agency. Dated May 27, 1997, agreeing to Delete the Monsanto Site from the National Priorities List.
- US Environmental Protection Agency, Superfund Remedial Design Fact Sheet, Monsanto Corp. Augusta Plant Site. Augusta, Georgia. Dated January 1993.
- US Environmental Protection Agency, Potential Hazardous Waste Site, Identification and Preliminary Assessment. Dated Dec 6, 1975.
- Monsanto Chemical Company. September 25, 1991. Letter Agreeing to Site Remedial Design Workplan Amendments.
- US Federal Register March 9, 1998, to Volume 63, Number 45. Page 11375 – 11376. Notice of Deletion of Monsanto Superfund Site front rational Priorities List.
- US Environmental Protection Agency, 12/7/91. Declaration for the Record of Decision. Signed by Region IV Administrator, Greer C Tidwell (later officially changed to 12/7/90).
- Monsanto Chemical Company. May 15, 1991. Proposed RCRA Permit Modifications.
- United States of America vs Monsanto Company, Civil Action 191-143. Dated October 8, 1991.
- US Environmental Protection Agency. March 28, 1991. Record of Decision, Summary of Remedial Alternative Selection. Monsanto Superfund Site, Augusta, Georgia.

Attachment B
Figures



CROSS-SECTION LOCATION MAP
Monsanto Augusta Plant Site
Remedial Investigation

FIGURE 1

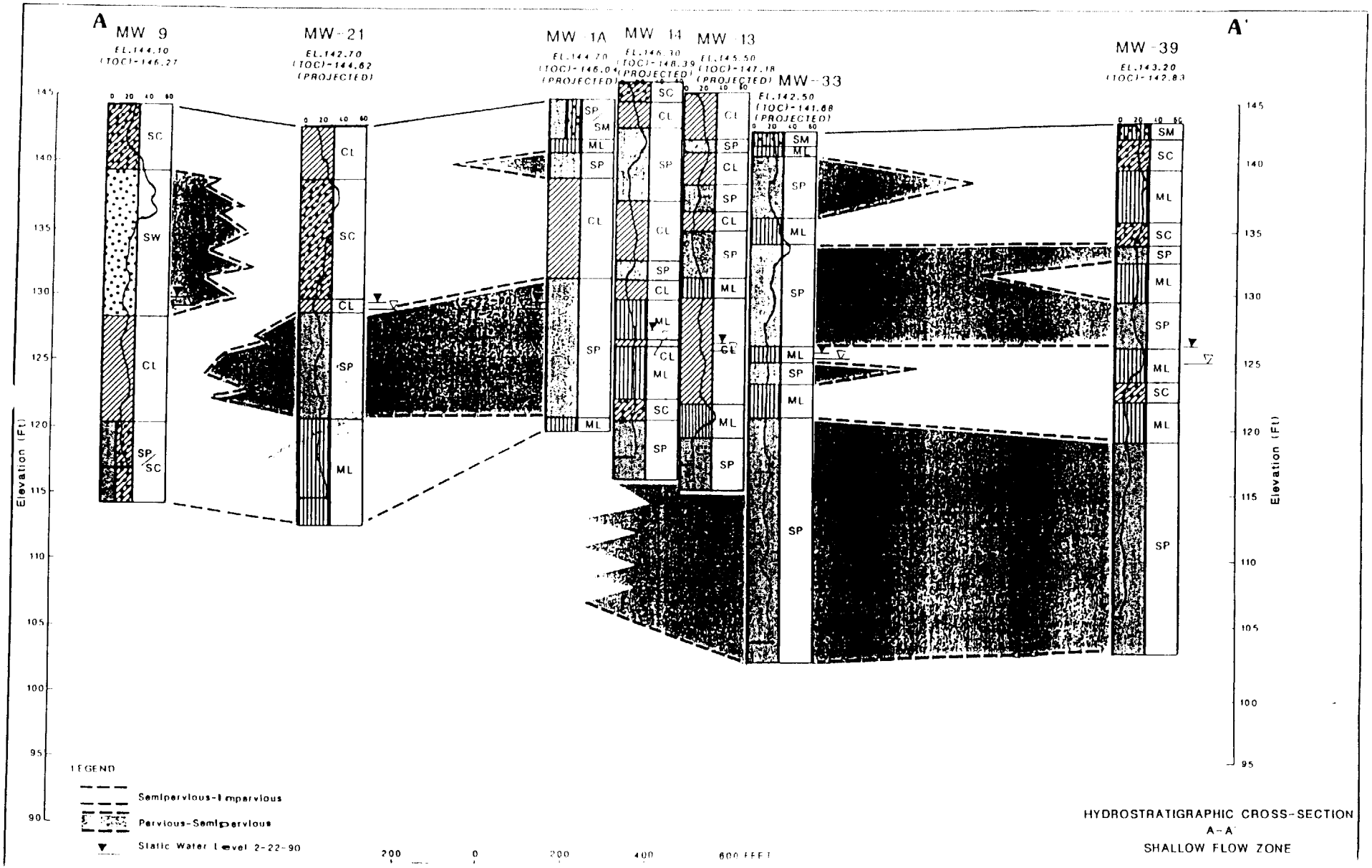
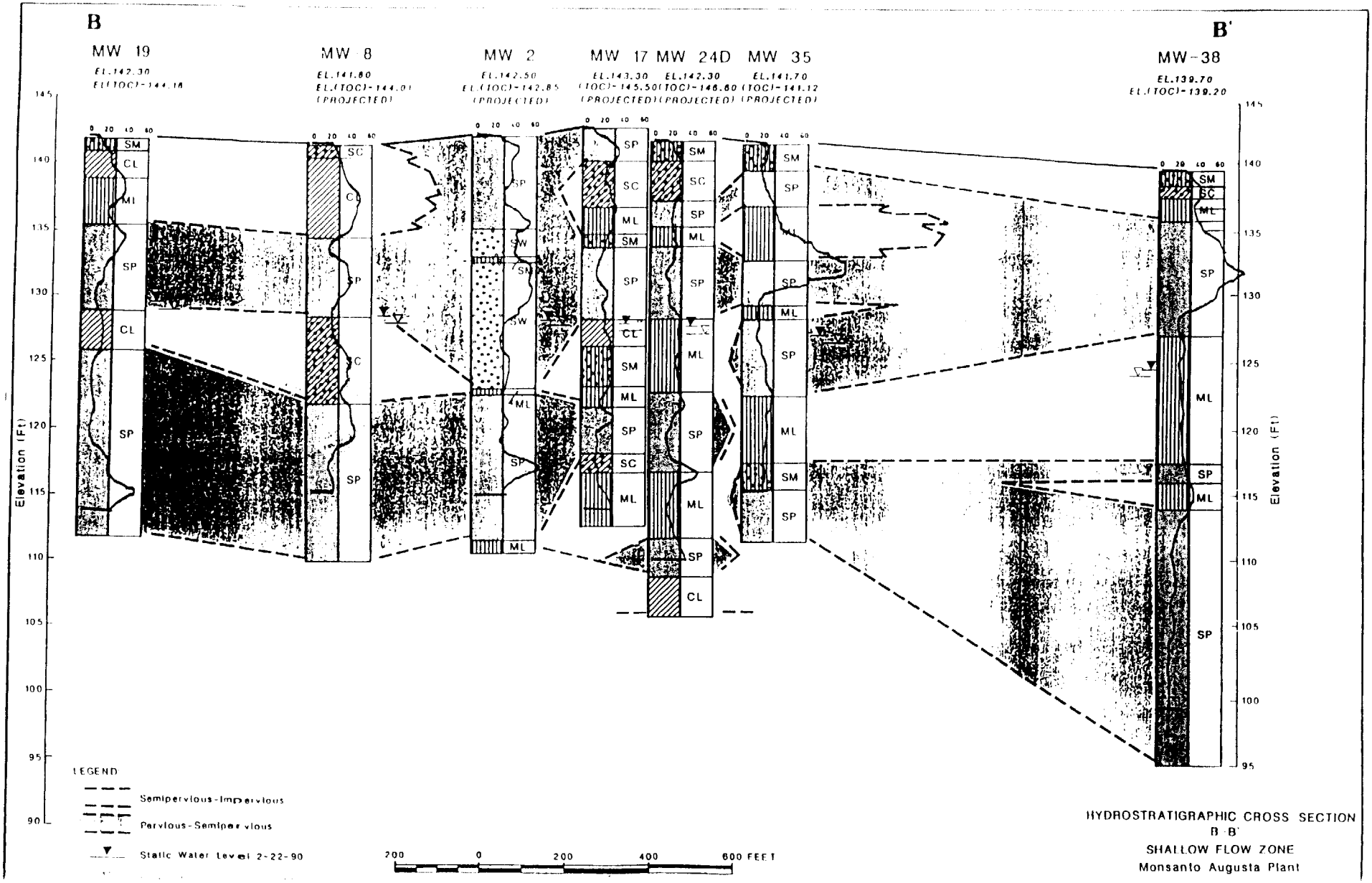

A
A'
MW 9
EL.144.10
(TOC)-146.27
MW-21
EL.142.70
(TOC)-144.62
(PROJECTED)
MW 1A
EL.144.70
(TOC)-146.04
(PROJECTED)
MW 14
EL.146.30
(TOC)-148.39
(PROJECTED)
MW 13
EL.145.50
(TOC)-147.18
(PROJECTED)
MW-33
EL.142.50
(TOC)-141.88
(PROJECTED)
MW-39
EL.143.20
(TOC)-142.83
Elevation (Ft)
LEGEND
Semipervious-Impervious
Pervious-Semipervious
Static Water Level 2-22-90
200 0 200 400 600 FEET
HYDROSTRATIGRAPHIC CROSS-SECTION
A-A'
SHALLOW FLOW ZONE

FIGURE 2



HYDROSTRATIGRAPHIC CROSS SECTION
B-B'
SHALLOW FLOW ZONE
Monsanto Augusta Plant

FIGURE 3

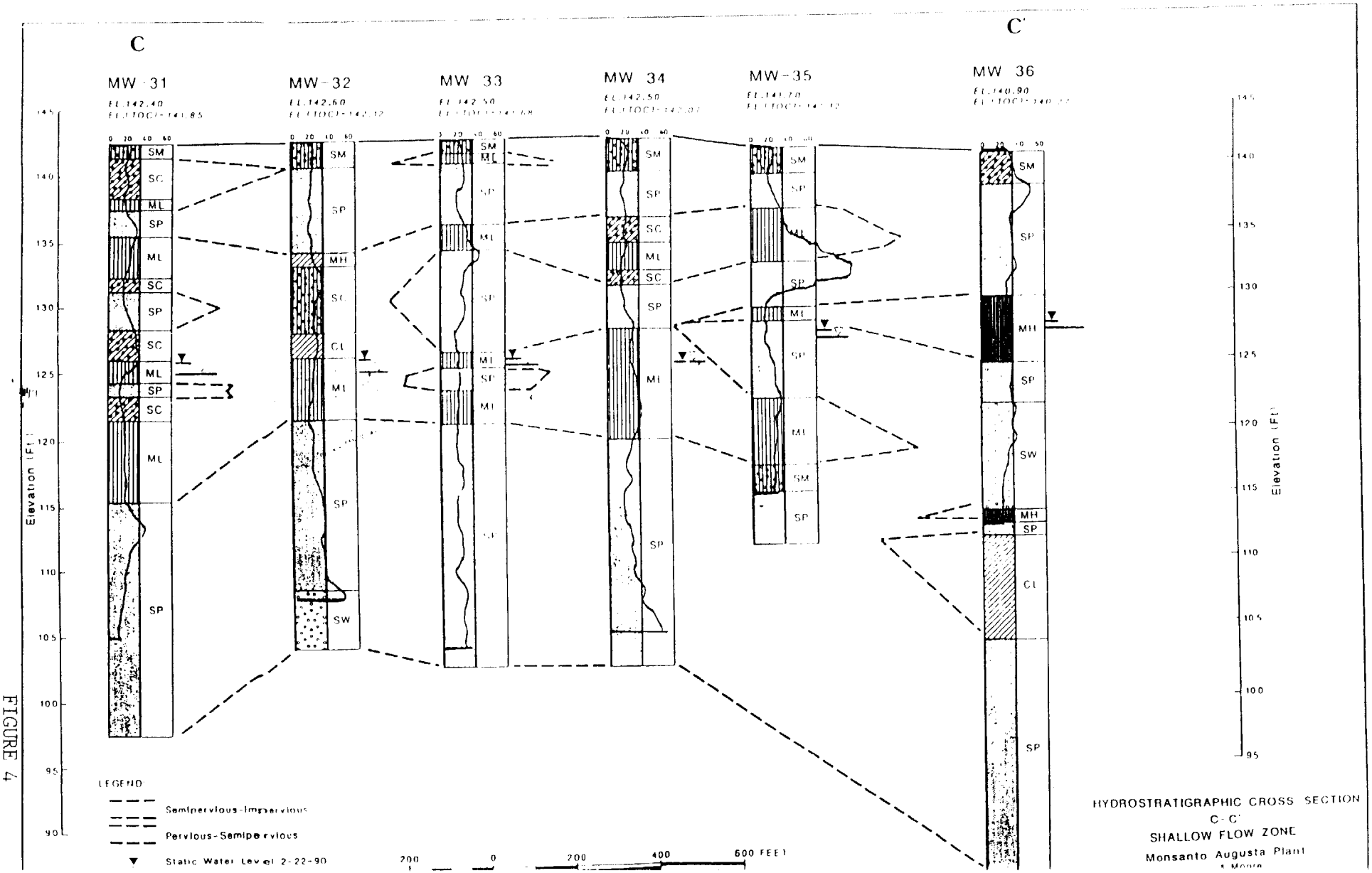
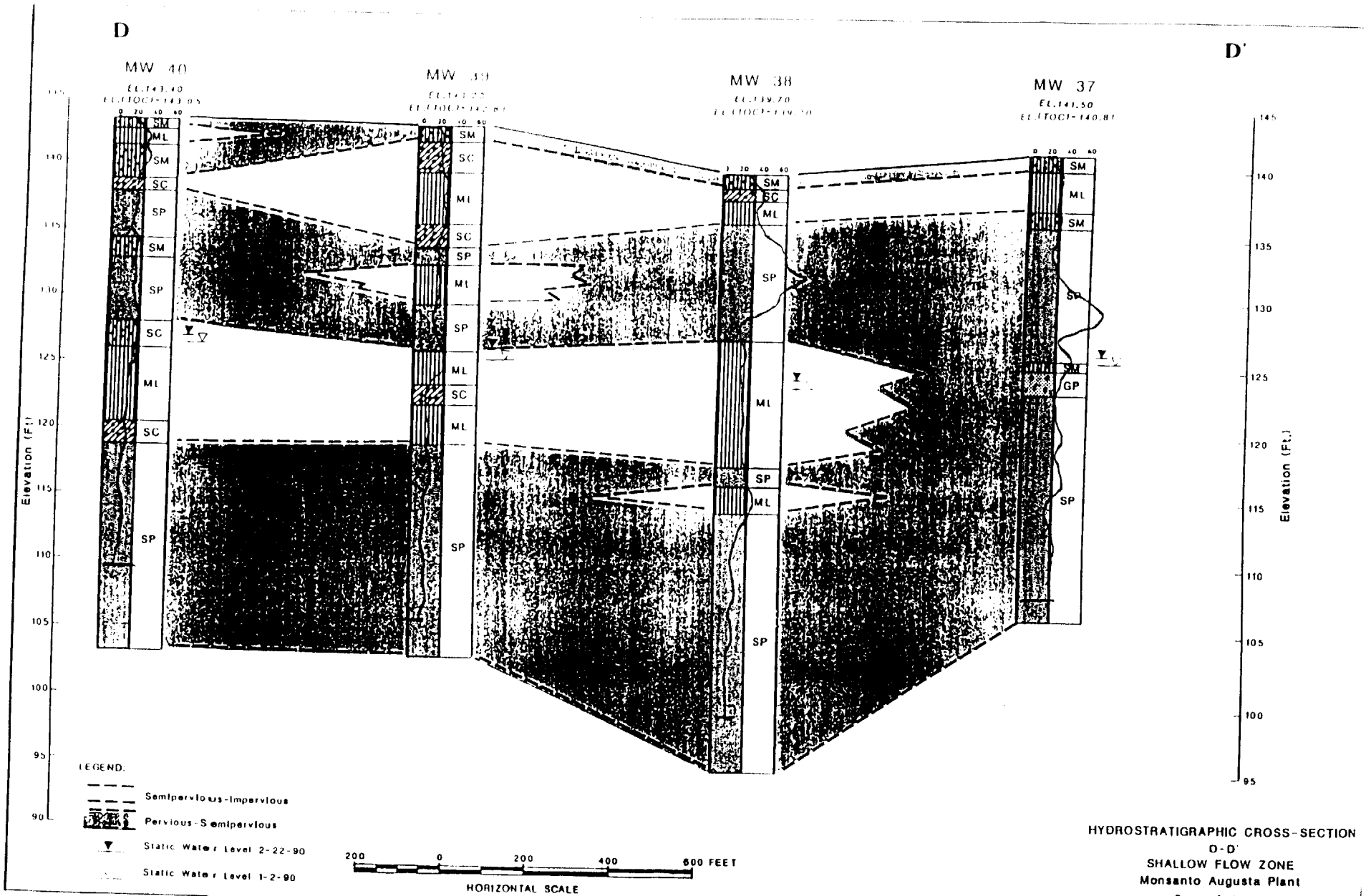


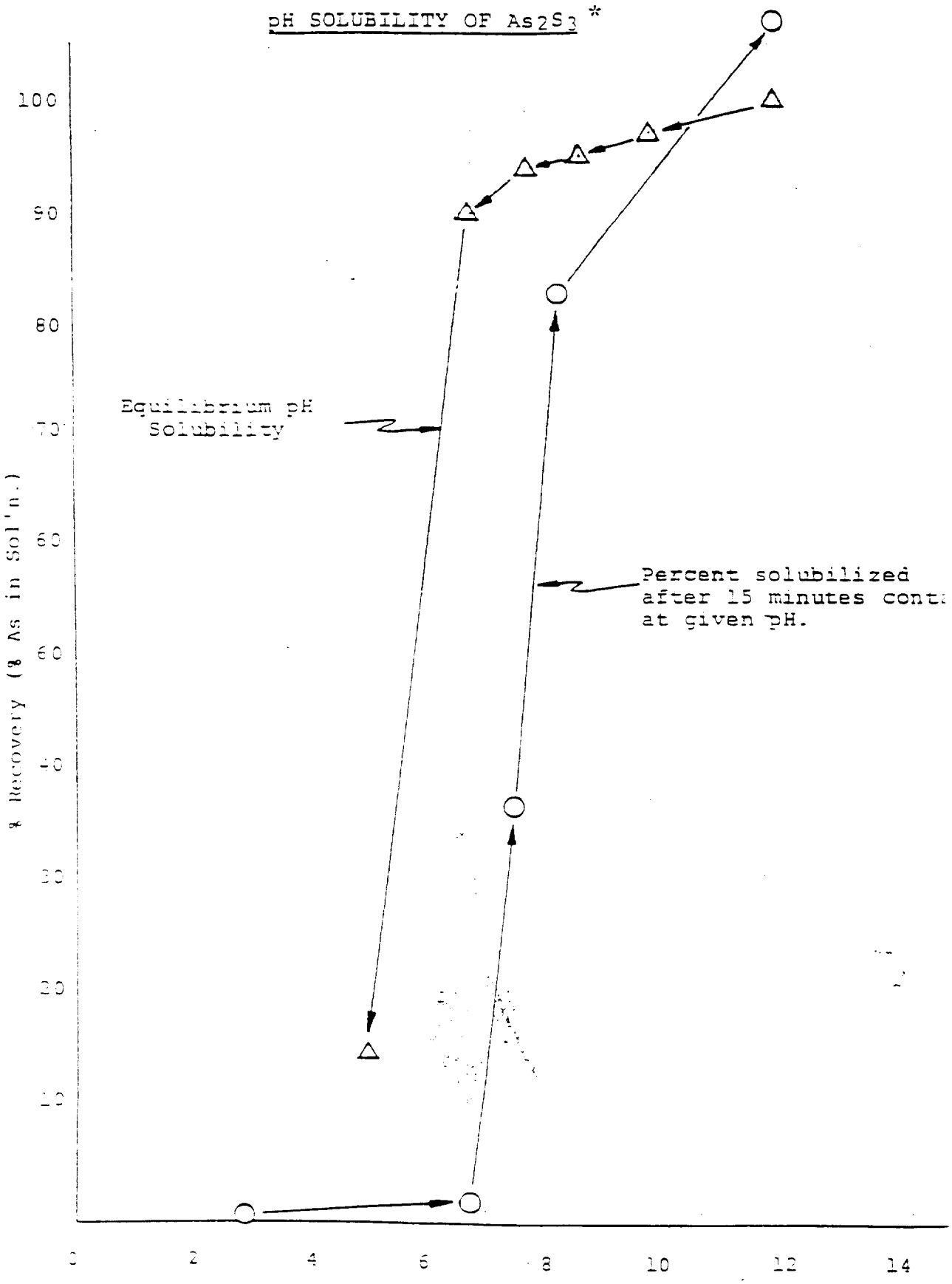
FIGURE 4

HYDROSTRATIGRAPHIC CROSS SECTION
C-C'
SHALLOW FLOW ZONE
Monsanto Augusta Plant



HYDROSTRATIGRAPHIC CROSS-SECTION
D-D'
SHALLOW FLOW ZONE
Monsanto Augusta Plant
Dames & Moore

FIGURE 5



*From C.R. Midyett, 1973, Laboratory data Monsanto Corp.

FIGURE 6

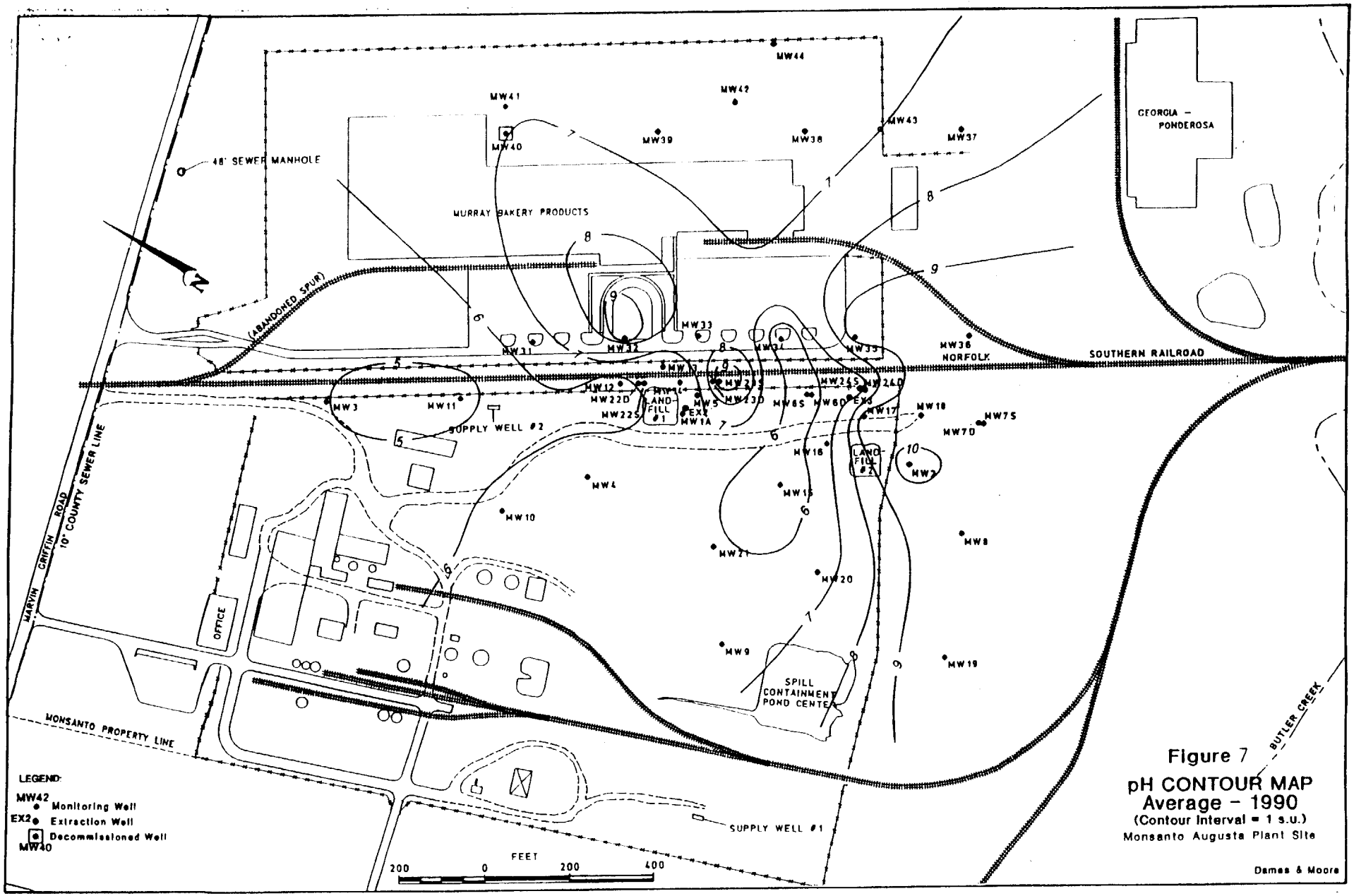


Figure 7

pH CONTOUR MAP
Average – 1990
(Contour Interval = 1 s.u.)
Monsanto Augusta Plant Site

Dames & Moore

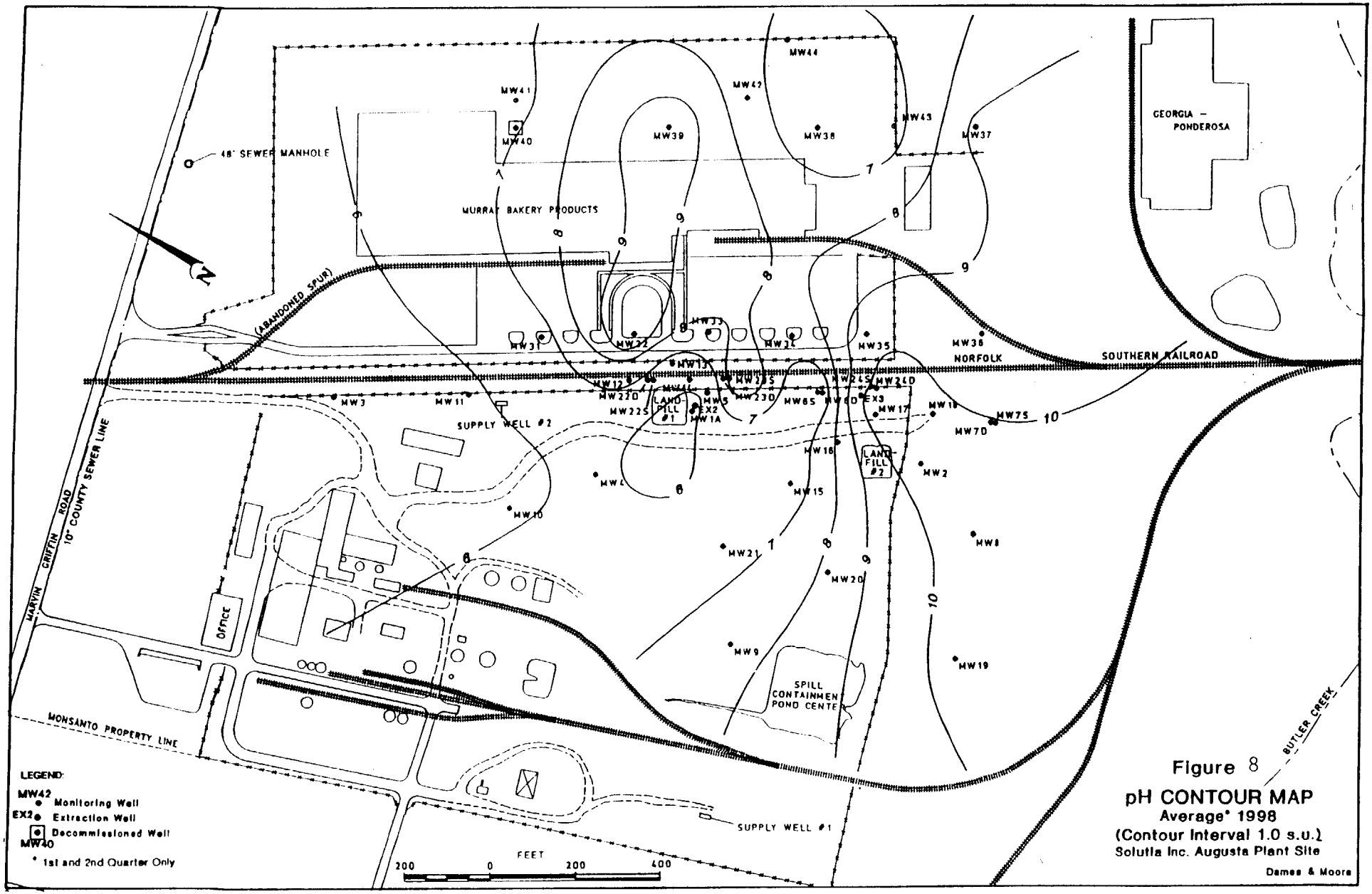


Figure 8

pH CONTOUR MAP

Average* 1998

(Contour Interval 1.0 s.u.)

Solutia Inc. Augusta Plant Site

Dames & Moore

Attachment C
Tables

TABLE 1
RECORD[i] OF ARSENIC RESULTS (µg/l)

WELL	Average As Concentration (April 1990-April 1993)	Average As Concentration (April 1993-April 1994)	Average As Concentration (April 1994-April 1995)	Average As Concentration (April 1995-April 1996)	Average As Concentration (April 1996-April 1997)	Average As Concentration (April 1997-April 1998)	Sixth Remedial Period			Period As Concentration (April 1998-April 1999)	Annual Rise (+) or Decline (-)
							Jul. 1998	Oct. 1998	Jan. 1999		
MW1A	64.33	87.00	63.75	5.00	11.75	9.25	5.00	27.00	33.00	21.67	12.42
MW2	19.23	35.75	43.50	24.50	39.00	39.75	21.00	24.00	25.00	23.33	-16.42
MW5	22.91	33.50	25.00	26.50	26.25	23.45	15.00	22.00	29.00	22.00	-1.45
MW6S	5.56	5.00	7.75	5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.00
MW6D	5.56	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.00
MW9	7.00	19.75	7.75	5.00	17.75	18.68	11.00	11.00	24.00	15.33	-3.34
MW12	8.25	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.00
MW13	20.17	17.25	20.00	19.25	18.00	17.45	5.00	16.00	20.00	13.67	-3.78
MW14	28.75	31.75	34.00	35.75	38.75	36.23	17.00	25.00	40.00	27.33	-8.89
MW15	9.09	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.00
MW17	53.69	42.25	37.13	32.00	50.25	76.64	27.00	20.00	30.00	25.67	-50.97
MW18	15.92	18.25	25.25	26.75	20.00	20.48	11.00	25.00	25.00	20.33	-0.14
MW19	16.25	25.00	26.75	25.75	18.50	27.65	28.00	27.00	28.00	27.67	0.02
MW23S	24.17	15.75	28.50	27.25	22.75	27.45	28.00	29.00	20.00	25.67	-1.78
MW23D	18.13	9.00	19.75	10.00	5.00	5.00	5.00	5.00	11.00	7.00	2.00
MW24S	117.31	17.75	20.88	48.00	51.13	62.70	42.50	42.50	49.50	44.83	-17.87
MW24D	41.82	75.25	39.00	33.00	37.00	41.55	41.00	45.00	57.00	47.67	6.12
MW31	14.54	18.25	17.25	18.00	15.00	13.25	5.00	12.00	14.00	10.33	-2.92
MW32	28.46	21.00	33.25	38.25	33.75	35.38	34.00	37.00	35.00	35.33	-0.04
MW33	27.23	26.25	36.25	29.00	43.50	28.73	18.00	24.00	25.00	22.33	-6.39
MW34	24.62	15.25	17.25	23.00	24.00	31.63	25.00	28.00	32.00	28.33	-3.29
MW35	42.18	47.00	32.75	28.75	44.25	21.48	5.00	23.00	33.00	20.33	-1.14
MW36	8.85	7.50	5.00	6.50	9.75	5.00	5.00	5.00	12.00	7.33	2.33
MW37	8.31	6.25	5.00	5.00	6.50	9.40	5.00	5.00	5.00	5.00	-4.40
MW38	25.08	30.00	19.75	29.75	22.75	18.05	11.00	16.00	25.00	17.33	-0.72
MW39	32.69	36.00	36.50	42.25	31.75	30.93	27.00	38.00	42.00	35.67	4.74
MW40	13.29	**DECOMMISSIONED AFTER OCTOBER 24, 1991**									
MW41	8.83	16.50	8.00	19.25	24.75	18.45	5.00	21.00	40.00	22.00	3.55

TABLE 1
(Continued)

WELL	Average As Concentration (April 1990-April 1993)	Average As Concentration (April 1993-April 1994)	Average As Concentration (April 1994-April 1995)	Average As Concentration (April 1995-April 1996)	Average As Concentration (April 1996-April 1997)	Average As Concentration (April 1997-April 1998)	Sixth Remedial Period			Period As Concentration (April 1998-April 1999)	Annual Rise (+) or Decline (-)
							Jul. 1998	Oct. 1998	Jan. 1999		
MW42	64.67	54.00	43.25	42.00	35.88	40.66	41.00	47.00	42.50	43.50	2.84
MW43	24.00	8.00	26.00	91.00	56.00	37.20	61.00	48.00	51.00	53.33	16.13
MW44		38.00	31.25	37.00	34.75	37.83	30.00	34.00	25.00	29.67	-8.16
EX2		57.00	35.25	29.25							
EX3		31.75	50.50	46.00	58.00	44.90	26.00	45.00	55.00	42.00	-2.90
WB1		32.50	44.50	35.50	43.00	43.68	29.00	40.00	43.00	37.33	-6.34
WB2		40.00	43.25	41.50	37.75	42.88	43.00	45.00	48.00	45.33	2.46
AVG.	26.70	26.03	25.35	25.81	26.35	25.78	18.53	23.27	27.35	23.05	-2.72
STD.DEV.	23.08	22.39	17.28	18.82	15.99	17.42	14.56	13.72	14.96	13.57	-3.86

* Abbreviated

\+ Averages do not include samples obtained at the weir boxes

TABLE 2
ARSENIC CONCENTRATION (µg/l) AT SELECT WELLS

AREA	Monitor Location	Avg. As Conc. (April 90- April 93)	Avg. As Conc. (April 93- April 94)	Total Discharge (gallons) (April 93- April 94)	Avg. As Conc. (April 94- April 95)	Total Discharge (gallons) (April 94- April 95)	Avg. As Conc. (April 95- April 96)	Total Discharge (gallons) (April 95- April 96)
I	MW1A	64.33	87.00		63.75		5.00	(290,220)
I	MW5	22.91	33.50		25.00		26.50	733,622
I	EX2		57.00	9,513	35.25	36	29.25	
I	P3						17.25	114,399
I	**Average**	**43.62**	**59.17**		**41.33**		**19.50**	
II	MW2	19.23	35.75		43.50		24.50	
II	MW17	53.69	42.25		37.13		32.00	
II	MW24S	117.31	17.75		20.88		48.00	
II	MW24D	41.82	75.25		39.00	1,745,110	33.00	1,003,582
II	MW35	42.18	47.00		32.75		28.75	
II	EX3		31.75	4,597,200	50.50	1,952,345	46.00	1,530,455
II	**Average**	**54.85**	**41.63**		**37.29**		**35.38**	
III	MW42	64.67	54.00	414,201	43.25	1,441,929	42.00	1,888,430
III	MW43	24.00	8.00		26.00		91.00	
III	MW44		38.00		31.25		37.00	
III	**Average**	**44.34**	**33.33**		**33.50**		**56.67**	
I and II	WB1		32.50		44.50		35.50	3,382,058
III	WB2		40.00		43.25		41.50	1,888,430
	WB1/WB2*		33.10		44.15		37.65	
	AVERAGE +	**50.02**	**43.94**		**37.35**		**35.40**	
	STD. DEV.	**28.77**	**21.32**		**11.40**		**19.53**	
	TOTAL GAL			**5,020,914**		**5,139,420**		**5,270,488**
	TOTAL CUMM. GAL					**10,160,334**		**15,430,822**

* weighted average based on flow

\+ average does not include weir boxes
(injection during period 5/04/95 to 10/20/95)

TABLE 2
(Continued)

AREA	Monitor Location	Avg. As Conc. (April 96- April 97)	Total Discharge (gallons) (April 96- April 97)	Avg, As Conc. (April 97- April 98	Total Discharge (gallons) (April 97- April 98)	Sixth Remedial Period			Avg. As Conc. (April 98- April 99)	Annual Rise (+) or Decline (-)	Total Discharge (gallons) (April 98- April 99)
						July 1998	Oct. 1998	Jan. 1999			
I	MW1A	11.75		9.25		5.00	27.00	33.00	21.67	12.42	
I	MW5	26.25	688,277	23.45	557,583	15.00	22.00	29.00	22.00	-1.45	553,292
I	EX2										
I	P3										
I	**Average**	**19.00**		**16.35**		**10.00**	**24.50**	**31.00**	**21.83**	**5.48**	
II	MW2	39.00		39.75		21.00	24.00	25.00	23.33	-16.42	
II	MW17	50.25		76.64		27.00	20.00	30.00	25.67	-50.97	
II	MW24S	51.13	341,451	62.70	764,206	42.50	42.50	49.50	44.83	-17.87	910,923
II	MW24D	37.00	279,189	41.55		41.00	45.00	57.00	47.67	6.12	
II	MW35	44.25		21.48		5.00	23.00	33.00	20.33	-1.14	
II	EX3	58.00	696,240	44.90	408,349	26.00	45.00	55.00	42.00	-2.90	432,090
II	**Average**	**46.60**		**47.84**		**27.08**	**33.25**	**41.58**	**33.97**	**-13.86**	
III	MW42	35.88	1,781,729	40.66	993,379	41.00	47.00	42.50	43.50	2.84	1,193,241
III	MW43	56.00	54,959	37.20	106,4014	61.00	48.00	51.00	53.33	16.13	100,241
III	MW44	34.75		37.83		30.00	34.00	25.00	29.67	-8.16	
III	**Average**	**42.21**		**38.56**		**44.00**	**43.00**	**39.50**	**42.17**	**3.60**	
I and II	WB1	43.00	2,005,107	43.68	1,730,138	29.00	40.00	43.00	37.33	-6.34	1,896,305
III	WB2	37.75	1,836,688	42.88	1,099,780	43.00	45.00	48.00	45.33	2.46	1,293,482
	WB1/WB2*	40.49		43.37					40.57	-2.80	
	AVERAGE +	**40.39**		**39.58**		**28.59**	**34.32**	**39.09**	**34.00**	**-5.58**	
	STD. DEV.	**21.26**		**18.60**		**17.08**	**11.35**	**12.21**	**13.55**	**-0.11**	
	TOTAL GAL		**3,841,795**		**2,829,918**						**3,189,787**
	TOTAL CUMM. GAL		**19,272,617**		**22,102,535**						**25,292,322**

* weighted average based on flow

\+ average does not include weir boxes
(injection during period 5/04/95 to 10/20/95)

TABLE 3

RECORD[i] OF WATER LEVEL ELEVATIONS

MONITOR WELL	Average WL (April 1990-April 1993)	Average WL (April 1993-April 1994)	Average WL (April 1994-April 1995)	Average WL (April 1995-April 1996)	Average WL (April 1996-April 1997)	Average WL (April 1997-April 1998)	Sixth Remedial Period			Average WL (April 1998-April 1999)	Annual Rise (+) or Decline (-)
							Jul-1998	Oct-1998	Jan-1999		
MW-1A	129.76	128.96	129.61	133.88	128.12	129.36	129.46	128.73	129.52	129.24	-0.12
MW-2	128.80	127.54	128.22	128.47	127.42	128.51	128.98	128.07	128.92	128.66	0.15
MW-3	131.76	128.95	132.34	131.80	130.19	132.60	131.28	130.33	133.87	131.83	-0.77
MW-4	128.85	127.77	128.67	128.84	127.63	128.67	128.99	128.22	129.42	128.88	0.21
MW-5	127.88	126.28	127.29	124.28	123.35	125.65	126.38	125.19	125.57	125.71	0.06
MW-6S	127.87	126.44	127.22	127.44	126.32	127.47	127.92	127.05	127.95	127.64	0.17
MW-6D	127.96	126.46	127.31	127.56	126.45	127.59	128.10	127.18	128.06	127.78	0.19
MW-7S	128.61	127.32	128.10	128.22	127.15	128.24	128.72	127.79	128.61	128.37	0.14
MW-7D	128.61	127.30	128.09	128.21	127.14	128.23	128.72	127.79	128.62	128.38	0.15
MW-8	128.98	127.81	128.56	128.71	127.74	128.66	129.15	128.26	129.04	128.82	0.16
MW-9	129.81	128.80	129.67	129.71	128.65	129.63	130.17	129.11	130.11	129.80	0.17
MW-10	129.91	128.81	130.35	131.07	130.29	131.77	132.45	131.56	132.97	132.33	0.56
MW-11	128.22	127.22	128.18	128.59	127.14	128.06	128.20	127.53	128.85	128.19	0.13
MW-12	127.67	126.07	127.23	127.78	125.65	127.54	129.88	128.96	128.04	128.96	1.42
MW-13	126.63	125.43	126.20	126.30	125.29	126.29	126.71	125.92	126.78	126.47	0.18
MW-14	127.69	126.12	127.07	125.69	124.59	126.37	126.90	125.81	126.50	126.40	0.04
MW-15	128.88	127.66	128.42	128.66	127.46	128.56	129.12	128.21	129.08	128.80	0.24
MW-16	128.17	126.82	127.57	127.78	126.72	127.81	128.29	127.38	128.25	127.97	0.16
MW-17	128.24	126.73	127.58	127.79	126.72	127.77	128.24	127.37	128.21	127.94	0.17
MW-18	128.50	127.14	127.95	128.09	127.01	128.12	128.60	127.69	128.53	128.27	0.16
MW-19	130.01	129.61	130.08	130.36	129.49	130.35	131.15	130.17	130.07	130.46	0.11
MW-20	129.42	128.24	128.98	129.21	128.02	129.07	129.71	128.75	129.50	129.32	0.26
MW-21	129.57	128.41	129.23	129.34	128.15	129.14	129.73	128.77	129.76	129.42	0.28
MW-22S	126.12	125.02	125.90	126.02	125.05	125.90	126.29	125.59	126.44	126.11	0.21
MW-22D	125.78	124.86	125.52	125.64	124.68	125.53	125.95	125.23	126.04	125.74	0.22
MW-23S	127.49	125.80	126.94	127.05	126.01	127.12	127.55	126.71	127.66	127.31	0.18

TABLE 3
(Continued)

MONITOR WELL	Average WL (April 1990-April 1993)	Average WL (April 1993-April 1994)	Average WL (April 1994-April 1995)	Average WL (April 1995-April 1996)	Average WL (April 1996-April 1997)	Average WL (April 1997-April 1998)	Sixth Remedial Period			Average WL (April 1998-April 1999)	Annual Rise (+) or Decline (-)
							Jul-1998	Oct-1998	Jan-1999		
MW-23D	126.00	125.21	125.60	125.71	124.74	125.59	125.98	125.24	126.18	125.80	0.21
MW-24S	127.98	126.35	127.17	127.45	126.34	127.38	127.70	127.01	127.83	127.51	0.14
MW-24D	128.06	126.55	117.85	118.71	122.72	127.60	128.07	127.21	128.06	127.78	0.18
MW-31	125.81	124.78	125.54	125.69	124.76	125.62	125.96	125.28	126.15	125.80	0.17
MW-32	125.86	124.79	125.55	125.71	124.73	125.59	125.96	125.28	126.12	125.79	0.20
MW-33	125.68		125.31	125.43	124.51	125.38	125.83	125.10	125.87	125.60	0.22
MW-34	125.30	124.15	124.89	125.07	124.11	124.93	125.33	124.63	125.45	125.14	0.21
MW-35	127.53	126.18	126.90	127.15	126.08	127.25	127.68	126.80	127.64	127.37	0.12
MW-36	128.12	126.80	127.57	127.77	126.69	127.82	128.28	127.32	128.20	127.93	0.11
MW-37	126.55	125.38	125.95	126.26	125.17	126.38	126.90	125.91	126.72	126.51	0.13
MW-38	124.20	123.09	123.80	123.90	122.98	123.86	124.30	123.55	124.32	124.06	0.20
MW-39	126.40	125.26	125.94	126.17	125.11	126.23	126.73	125.81	126.65	126.40	0.16
MW-40	126.36	**DECOMMISSIONED OCTOBER 24, 1991**									
MW-41	127.38	125.79	126.61	126.85	125.68	126.73	127.14	126.31	127.15	126.87	0.14
MW-42	124.73	122.70	119.47	118.20	115.24	118.80	120.36	119.35	115.80	118.50	-0.29
MW-43	124.69	122.98	123.70	123.81	117.45	116.45	119.88	115.28	115.14	116.77	0.32
MW-44		123.13	123.47	123.57	122.67	123.50	123.93	123.21	124.00	123.71	0.22
EX-1	128.41	126.34	127.18	127.45	126.37	127.53	127.96	127.13	128.00	127.70	0.16
EX-2	132.91	128.09	128.95	129.32	127.27	128.61	129.59	128.89	129.81	129.43	0.82
EX-3	130.95	121.07	121.72	120.97	121.57	116.88	117.40	120.88	121.43	119.90	3.02
PRO2	121.08	120.41	120.55	121.26	120.48	121.88	123.02	123.22	122.33	122.86	0.98
AVG+	**127.76**	**126.24**	**126.79**	**126.94**	**125.76**	**126.80**	**127.37**	**126.52**	**127.26**	**127.05**	**0.25**
STD	**1.63**	**1.85**	**2.68**	**3.00**	**2.77**	**3.09**	**2.81**	**2.80**	**3.30**	**2.92**	**-0.17**

* Abbreviated

\+ Average does not include Production Well #2 (PRO2)

Attachment D
Data Analysis

Data Analysis

This data analysis was conducted to attempt to further an understanding of the ground water arsenic concentration data, and its relationship to observed ground water pH. The analysis is based on the data reviewed as part of the five year review.

Three monitoring wells were identified where recently acquired ground-water arsenic concentration data indicated above-MCL arsenic concentrations. These wells are MW24D, MW43, and well EX3. Figure 1 shows data for just these three wells. The last points on the figure represent the averages from Table 1 of Attachment C, data from July 1998, October 1998, and Januarv 1999. The three trend lines represent the "best estimate" of the trend in arsenic concentration over time. However, for all three observations, simple linear regression analysis with the sample date as a predictor of arsenic concentration shows very large ranges in the potential slope and y-intercept values at a confidence level of 95% (statistics presented to Table I of this analysis). This more detailed statistical evaluation of data from these wells indicates that the sample date is a poor predictor of the ground-water arsenic concentration at the three wells. Based on this analysis, it could be concluded that there is no trend with respect to the arsenic concentration in samples from these wells that can be shown using the data from Table 1 of Attachment C.

A second approach to analysis of data in Attachments B & C is to consider a larger group of monitoring well data, to determine if there are any site-wide trends, or correlations between the ground-water pH and the arsenic concentration. Several data analysis techniques were used to make this more general evaluation of site ground-water quality conditions. These techniques are documented in the following discussions.

1. **Plot of the Approximate Difference in the Ground-Water pH versus the Difference in the Dissolved Arsenic Concentration; 1990 to 1998 Data.**

Figure 2 shows a plot of the approximate difference in the ground-water pH at various monitoring wells between 1990 and 1998, as estimated from pH contour plots presented as Figure 7 and Figure 8 in Attachment B, versus the difference in the reported average arsenic concentration, as calculated from monitoring well data included to Attachment C, Table 1. For those arsenic data, the three data points from the "sixth remedial period" were averaged to estimate the 1998 average arsenic concentration, while the reported average arsenic concentration for the 1990 to 1993 monitoring period was used to represent the arsenic concentrations for 1990.

Figure 2 shows that where there has been a substantial increase in pH from 1990 to 1998, there is generally a modest increase in the average arsenic concentration. However, for one of the observations with the largest increases to pH, the greatest decrease in the average arsenic concentration was observed. One would anticipate that where the ground-water pH decreased, there would be a decrease in the average arsenic concentration, if there is a field-scale relationship between the two variables.

Figure 2 indicates that if there is any arsenic-pH correlation, it is very weak, although it cannot be ruled out that such a correlation may occur on a localized basis. As a general comment, Figure 2 does not show any relationship between the change in arsenic concentration and the approximate change in pH, for a comparison of the available data.

Figure 1. Average Arsenic Concentrations Over Time, Wells with Recent Arsenic Concentrations Above the 50 ug/L MCL

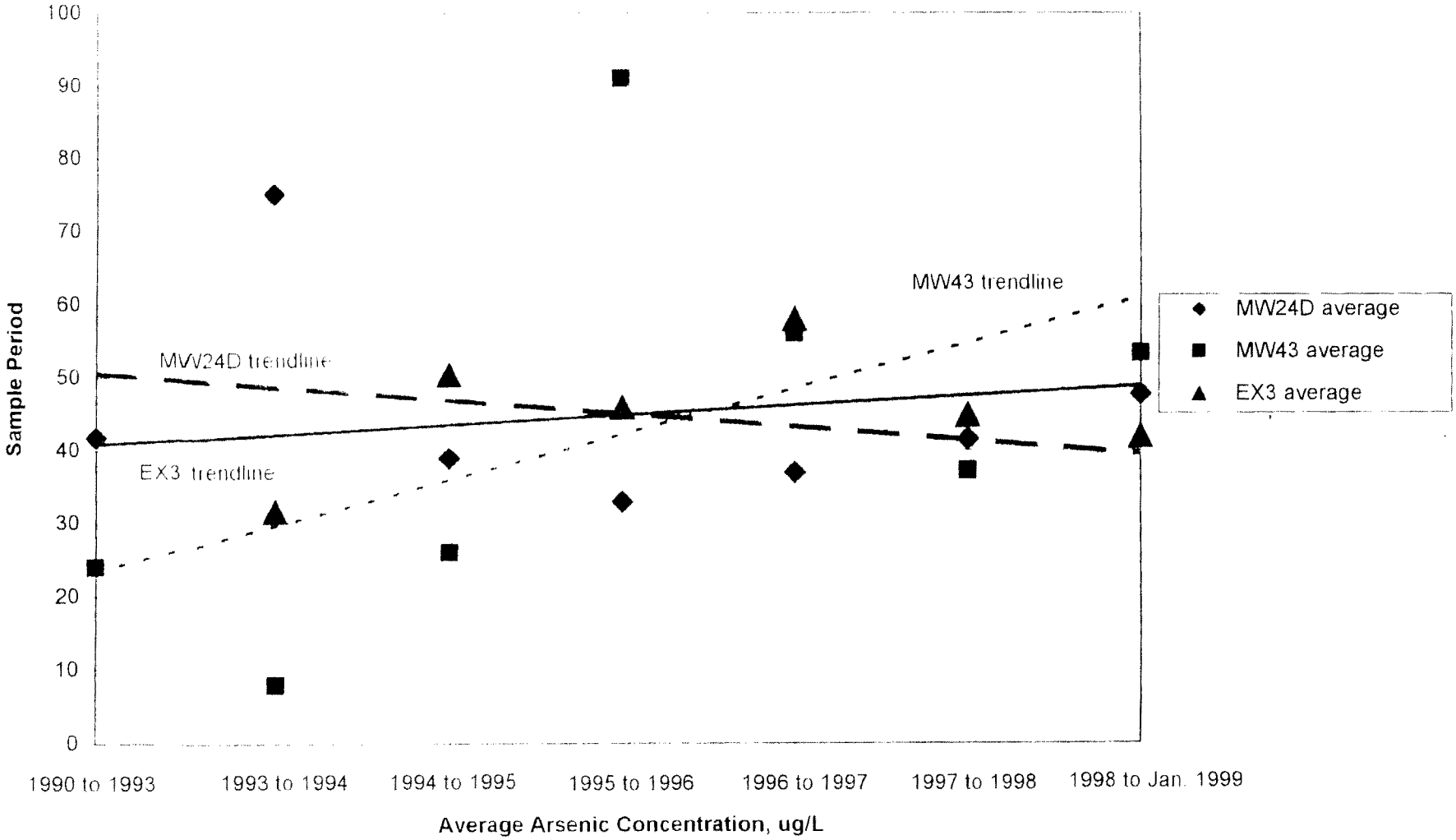


Figure 2. Approximate Difference in pH versus Difference in Arsenic Concentration, Comparison of 1990 Data to 1998 Data *

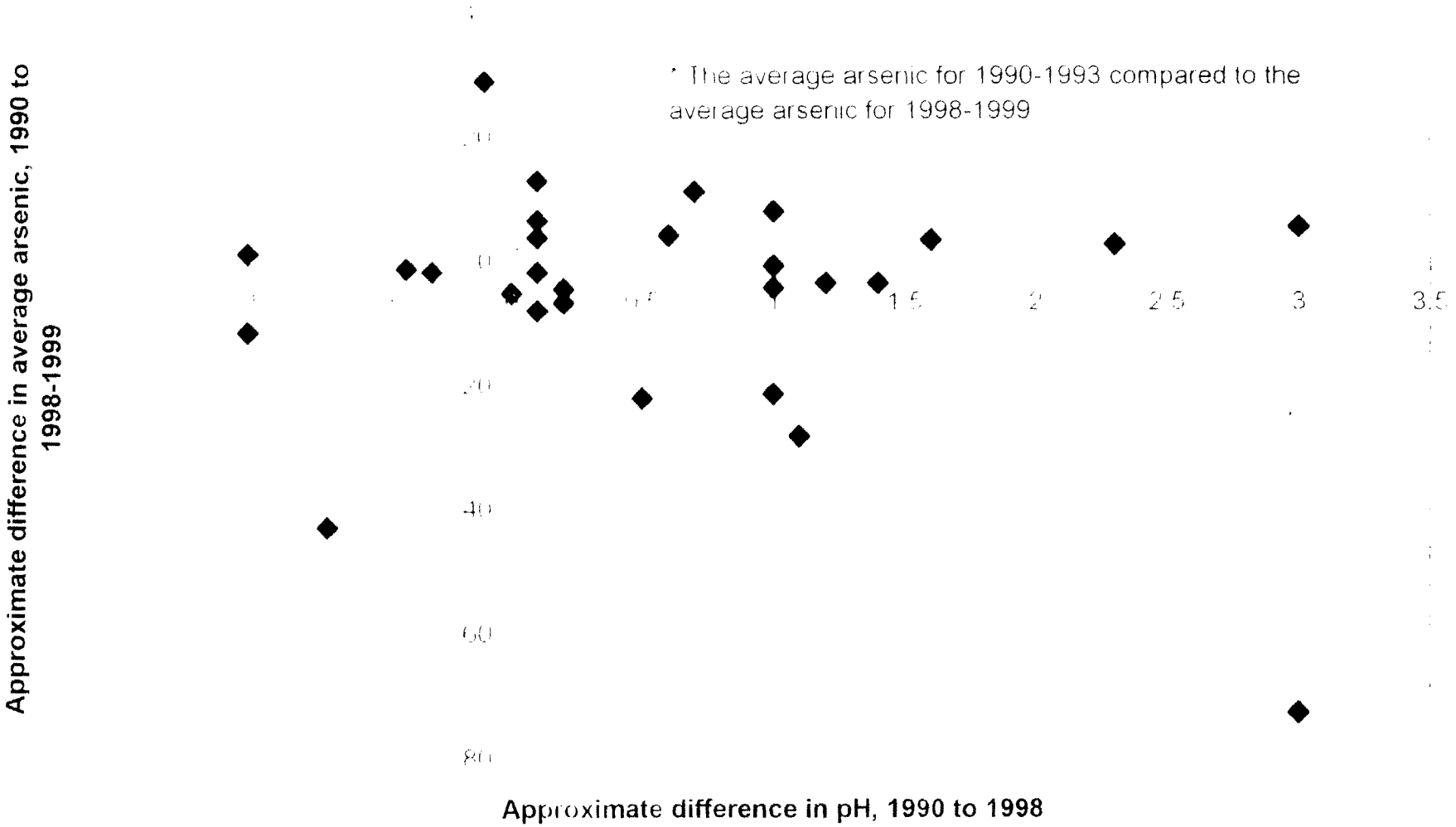


Table I. Statistics for Regression Analysis of Observed Average Arsenic Concentration versus Sample Date

1. MW24D Average Arsenic versus Sample Date

Sample Date*	Average Arsenic Concentration
1991.5	41.82
1993.5	75.25
1994.5	39
1995.5	33
1996.5	37
1997.5	41.55
1998.5	47.7

* average date for sample interval (e.g. 1994-1995 data are given a sample date of 1994.5)

Statistics
R^2 0.0569
m = -1.3924; 95% upper confidence = 5.126 95% lower confidence = -7.911
b= 2823; 95% upper confidence = 15830 95% lower confidence = -10184

2. MW43 Average Arsenic versus Sample Date

Sample Date*	Average Arsenic Concentration
1991.5	24
1993.5	8
1994.5	26
1995.5	91
1996.5	56
1997.5	37.2
1998.5	53.3

* average date for sample interval

Statistics
R^2 0.0242
m = 5.58033; 95% upper confidence = 16.9307 95% lower confidence = -5.77
b= 1 1092; 95% upper confidence = 11555 95% lower confidence = -33740

3. EX3 Average Arsenic versus Sample Date

Sample Date*	Average Arsenic Concentration
1993.5	31.75
1994.5	*50.5*
1995.5	46
1996.5	58
1997.5	44.9
1998.5	42

* average date for sample interval

Statistics
R^2 0.0804
m = 1.327; 95% upper confidence = 7.556 95% lower confidence = -4.902
b= -2603; 95% upper confidence = 9830 95% lower confidence = -15037

2. Plot of the Approximate pH versus the Average Arsenic Concentration, Comparison of the 1990 and 1998 Data

Figure 3 shows a plot of the approximate pH at various monitoring wells versus the average arsenic concentration, for the 1990 (arsenic 1990 to 1993 average) and 1998 (arsenic average for the sixth remedial period) data. The statistics for these two periods show an increase in the pH as a general site trend (a parametric statistical test for comparison of means was done that indicates a significant difference in mean pH at an % probability level of 0.05). However, as a general trend, the average arsenic concentration (the arithmetic mean or median of averaged individual values) has apparently either decreased or remained the same from 1990 to 1998. This arsenic trend is counter to that which would be predicted from a positive correlation between the pH and the arsenic concentration.

3. Spatial Distribution of Arsenic and pH

The spatial distribution of arsenic concentrations and approximate ground-water pH values may provide another line of evidence concerning the change in arsenic concentration over time and its relationship to the ground-water pH. Figure 4 shows the approximate distribution of groundwater arsenic from the average of the 1990 to 1993 data in Table 1 of Attachment C. The pH data shown on the figure are point estimates based on pH contours shown on Figure 7 of Attachment B. Figure 4 shows three localized areas of above MCL average arsenic concentrations. These areas are centered on monitoring wells MW24S, MW 1A, and MW42. The approximate pH in these areas was in the range of 5.9 to 7. 0. Figure 4 does not suggest a correlation between the pH and the observed arsenic concentration in the 1990 data. However, it is possible that at that time, the higher pH ground water that is localized to the south and east of the high ground-water arsenic concentration areas had not yet contacted most of the available arsenic mass that could be solubilized.

Figure 5 shoes the relationship between the spatial distribution of average arsenic concentrations and ground-water pH for the 1998 data. In this case, the average arsenic concentration represents the average of individual observations made in July and October 1998 and January 1999 (Attachment C, Table 1). A comparison of Figure 5 to Figure 4 indicates that the highest pH values are still generally found in areas to the south of the site. However, there are several notable increases in the pH in areas located to the east and northeast of the site (MW39 and MW37), and there is a notable increase in the pH in the area where the highest arsenic concentrations were observed for the 1990-1993 average (MW24S). Generally, the concentrations of arsenic appear to be decreasing over time, based on the comparison of Figure 5 to Figure 4. However, there are locally notable increases in the average arsenic concentration, particularly at MW43. The increase in arsenic concentration at MW43 cannot be tied to an increase in the pH. At MW42 and MW24S, an apparent increase in pH between 1990 and 1998 is associated with a declining average arsenic concentration. At MW1A, the arsenic concentration has also decreased, but the pH appears to have decreased as well. Overall, there is no definable relationship between arsenic and pH that can be discerned from a comparison of Figure 4 to Figure 5

4. Arsenic Concentration Trends for Observations Separated into low pH/low pH change and high pH/high pH change categories

A final data analysis approach considered arsenic concentration trends that might be discernable if observations were separated into two categories: low pH/low pH change and high pH/high pH change. These categories were qualitatively defined by adding the magnitude of pH change from 1990 to 1998

Figure 3. Approximate pH versus Average Arsenic Concentration

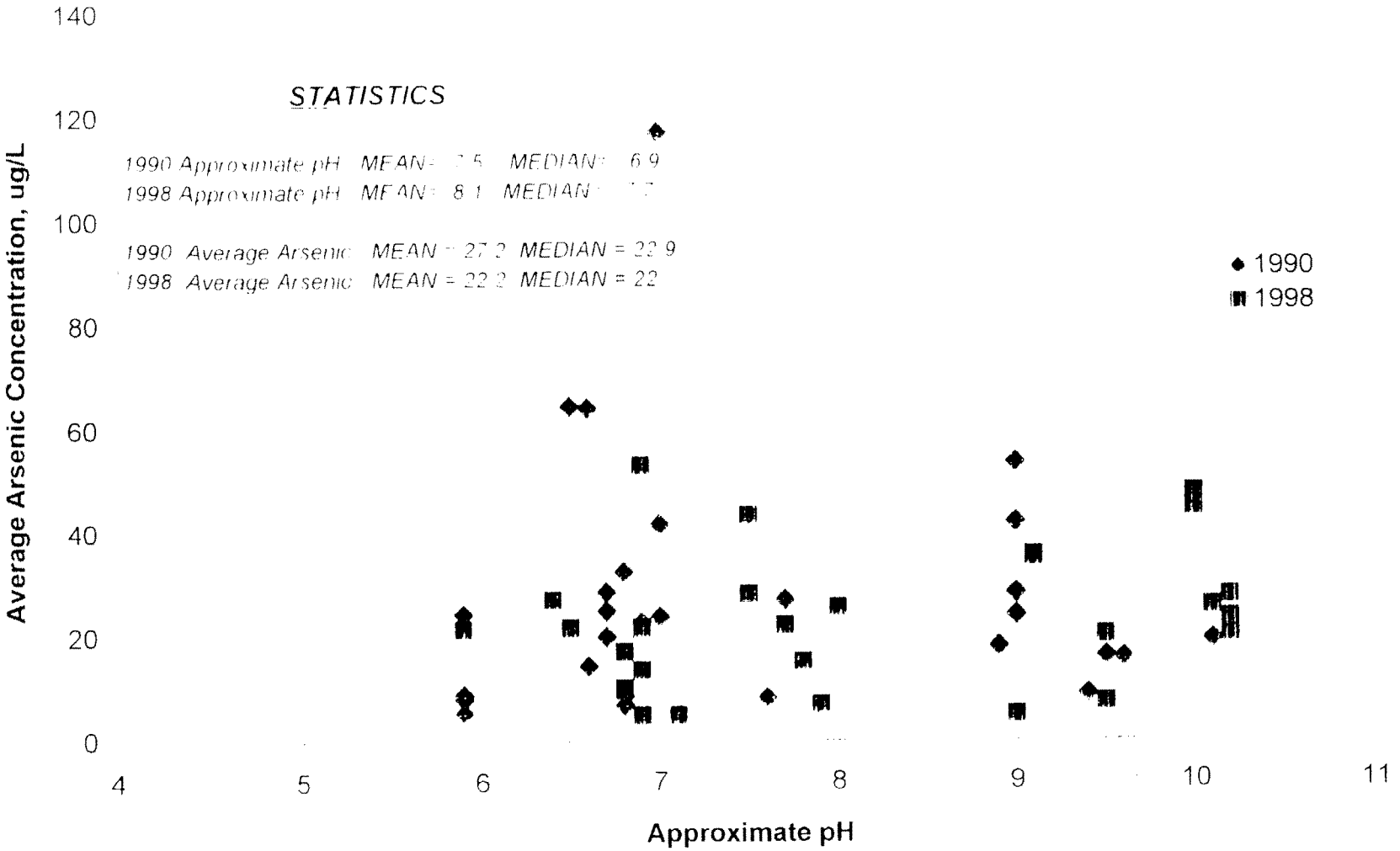
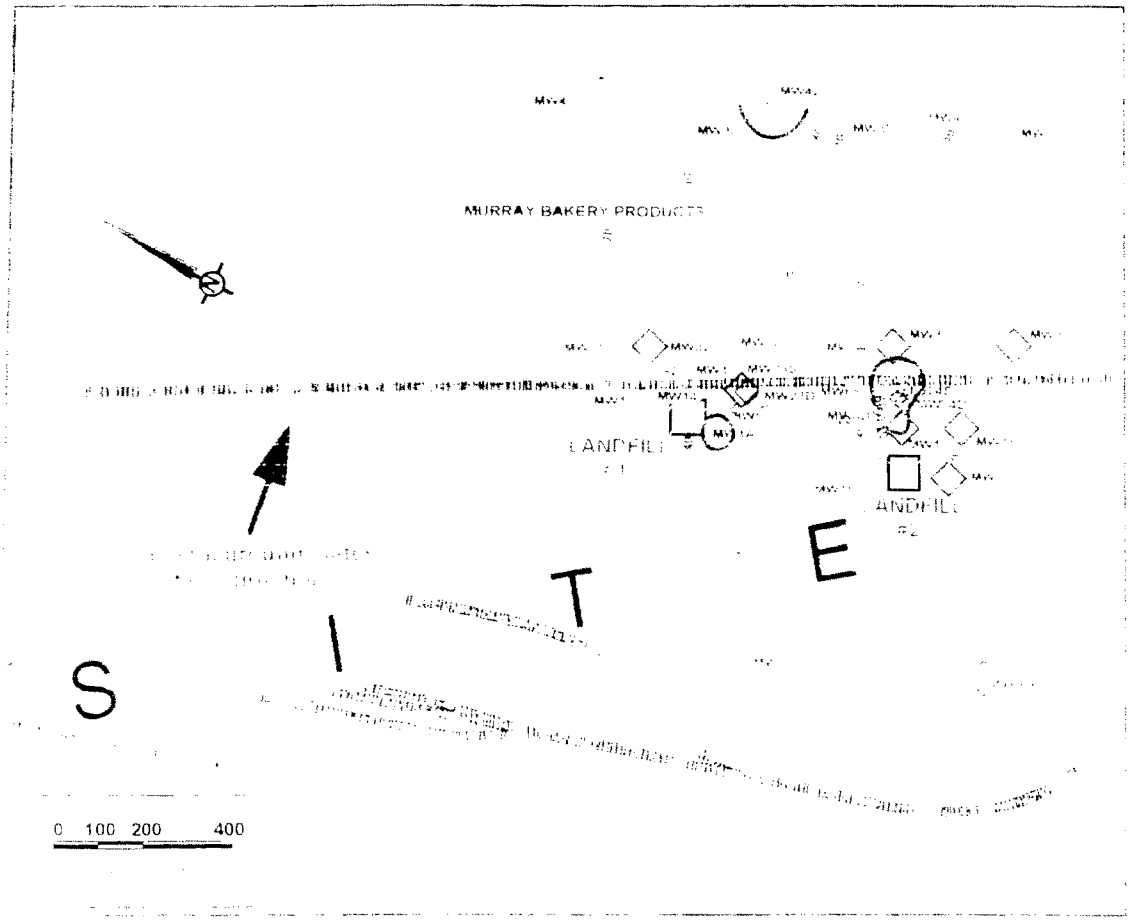


Figure 4. Comparison of Arsenic Concentration Contours to Estimated pH Values, 1990 Data



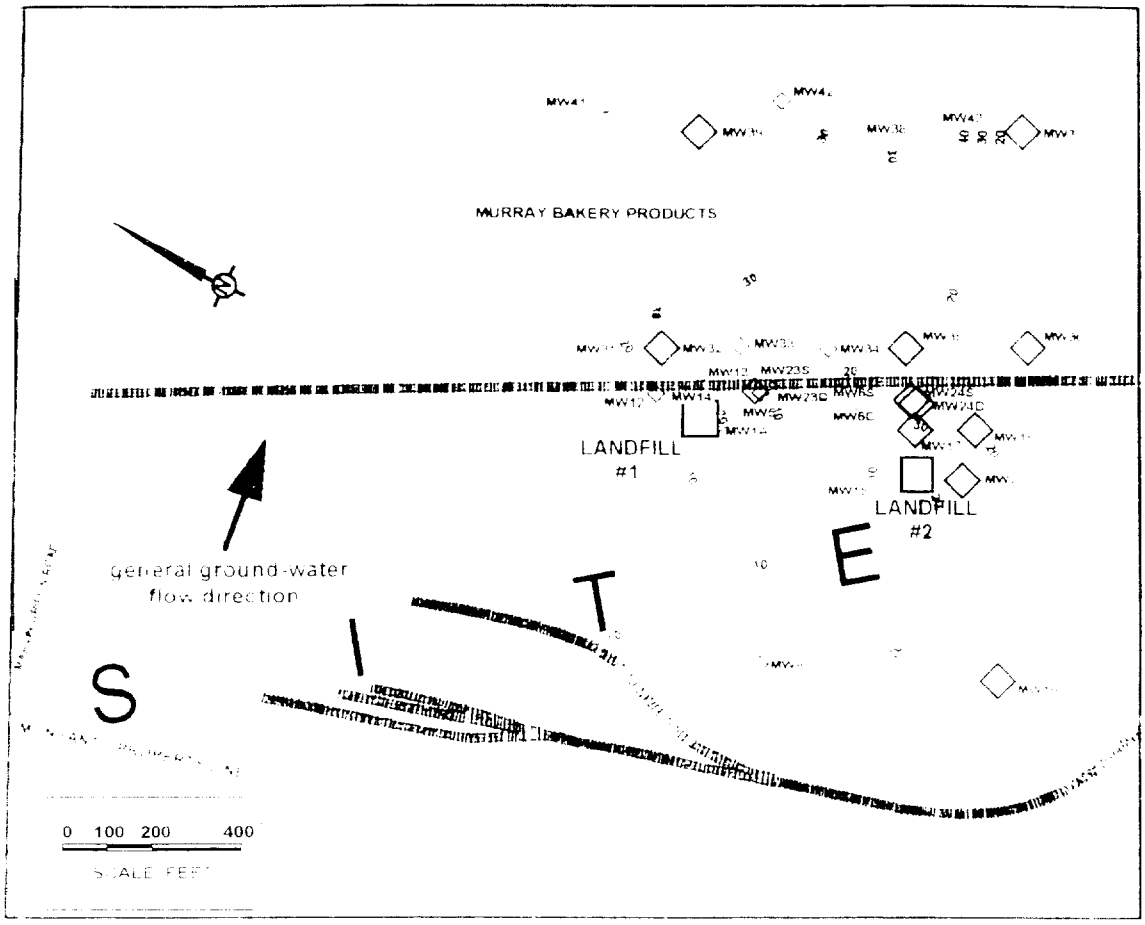
Estimated pH Ranges, 1990 Data

5.9 to 7.0
7.0 to 8.0
8.0 to 9.0
9.0 to 10.2

Arsenic Concentration Contours (ug/L) based on the average of the 1990 to 1993 data from Table 1 of the Revised Five-Year Review Report

50 ug/L arsenic concentration contour

Figure 5. Comparison of Arsenic Concentration Contours to Estimated pH Values, 1998 Data



Estimated pH Ranges, 1998 Data

5.9 to 7.0
7.0 to 8.0
8.0 to 9.0
9.0 to 10.2

Arsenic Concentration Contours (ug/L), 1998 Data

estimates to the approximate 1998 pH values. Observations with a 1998 pH below 9.0 were excluded from the high pH/high pH change data set, while observations with a sum of the l998 pH and the 1990 to 1998 pH concentration change above a value of 8 were excluded from the low pH/low pH change data set. Also excluded from this analysis were observations where there was no detection of arsenic in the 1998 -1999 data (e.g. MW 15, which would otherwise qualify for the low pH/low pH change data set).

The results of this data evaluation are presented on Figure 6 through Figure 9. Figure 6 shows the average arsenic concentrations at different times for the low pH/low pH change observations; Figure 7 shows the trend lines (best guess estimates of the underlying trends) for the data shown on Figure 6. Taken together, these figures show that generally, arsenic concentrations in areas with low ground-water pH and minimal influence from the reported high pH ground water encroaching on the area of concern are probable decreasing over time. As shown on Figure 7, the sole exception to this generalization may be MW43, where there are indications of an increasing arsenic concentration over time. Figures 8 and 9 are correlative to Figure 6 and Figure 7, but represent the results from observations that are defined as high pH/high pH change. Comparing Figure 8 to Figure 6, it appears there is more of a range in average arsenic concentrations at any specific time period for the high pH/high pH change observations, compared to the low pH/low pH change observations. This situation may reflect some measurable influence of ground-water pH on arsenic concentrations in at least some of the high pH/high pH change sample locations. However, the specific cause for the greater variation in arsenic concentration for the high pH/high pH change observations is unknown. Figure 9 shows the trend lines for the high pH/high pH change observations. There may be a trend of increasing arsenic concentrations over time for a few of these observations. However, most of the trend lines show such minimal slope that no conclusion can be made about the possibility of either a positive or negative trend. The most dramatic apparent increasing trend is observed for the MW24S data. This apparent trend is more dramatic than the apparent increasing arsenic concentration trend shown on Figure 7 for MW43. Regardless of the possible trends shown on Figure 7 and Figure 9, it can be concluded there is a high degree of uncertainty regarding any arsenic concentration trend in the ground water at any sample location. This statement is made on the basis of the earlier statistical analysis of the MW43 data (Table I) where the trend line slope and y-intercept values were determined to be very uncertain.

Summary and Conclusions

The evaluation in this memorandum report is based only on the data contained in the FiveYear Review Report. Those data are incomplete with respect to the ground-water quality data that have been obtained from the site, but are sufficient such that reasonable conclusions may be made about the site ground-water quality and the need for any adjustments to the site ground-water remedial action.

To summarize the data review in this analysis, there are no compelling data that indicate an increasing ground-water arsenic concentration in response to increasing ground-water pH at the Monsanto site. A possible reason for the apparent lack of correlation between the ground-water pH and arsenic concentrations is the removal of a large part of the subsurface arsenic mass over time, due to soil remedial actions and to the operation of the ground-water extraction system. Thus, with less arsenic mass available, concentrations of dissolved arsenic in the ground-water may have generally decreased or remained stable over time, regardless of the change in pH. Available data do show an overall increase in the ground-water pH from 1990 to 1998.

Figure 6. Average Arsenic Concentrations at Different Times for low pH/low pH change Observations

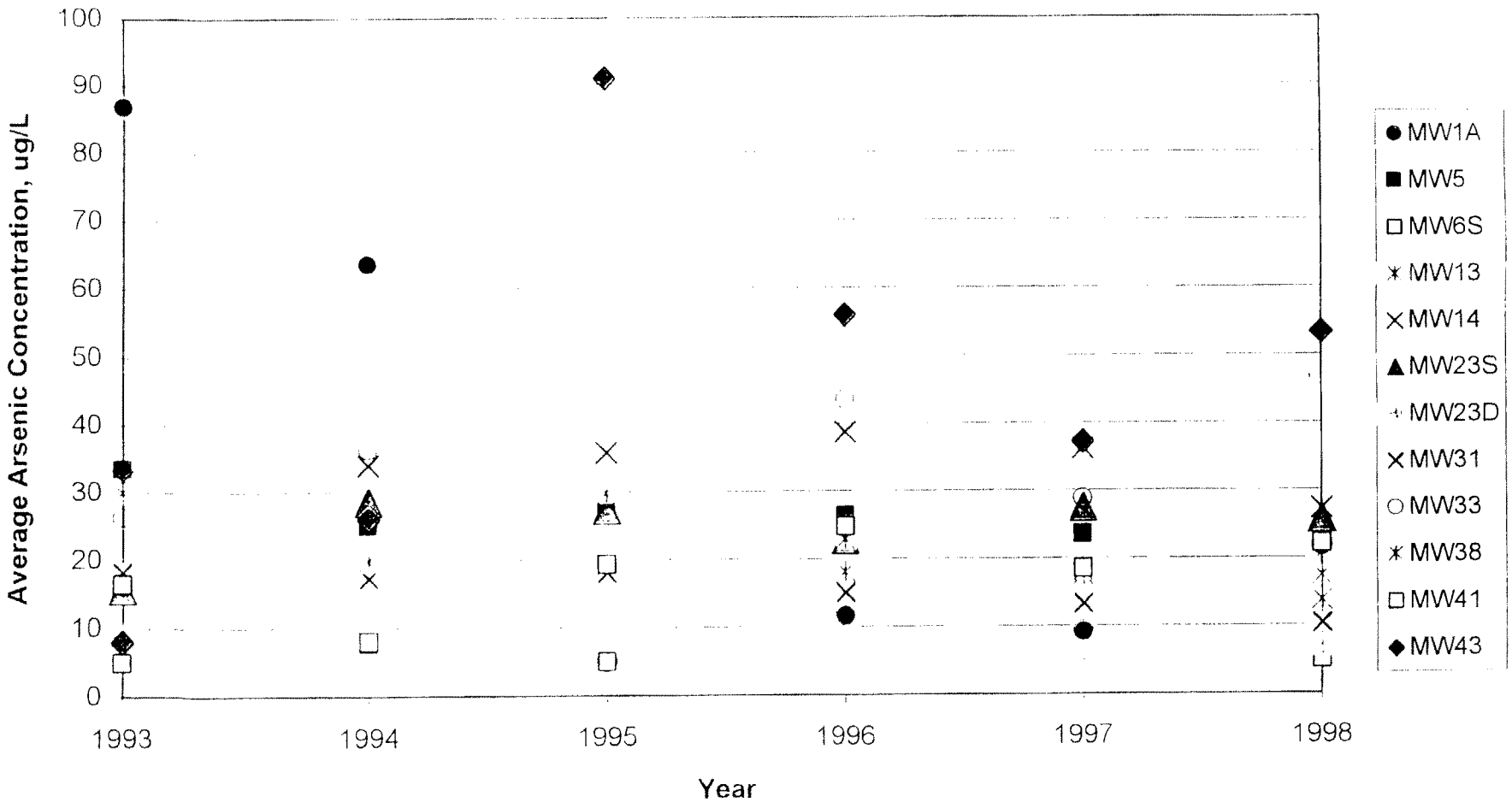


Figure 7. Arsenic Concentration Trend Lines for low pH/low pH Change Observations

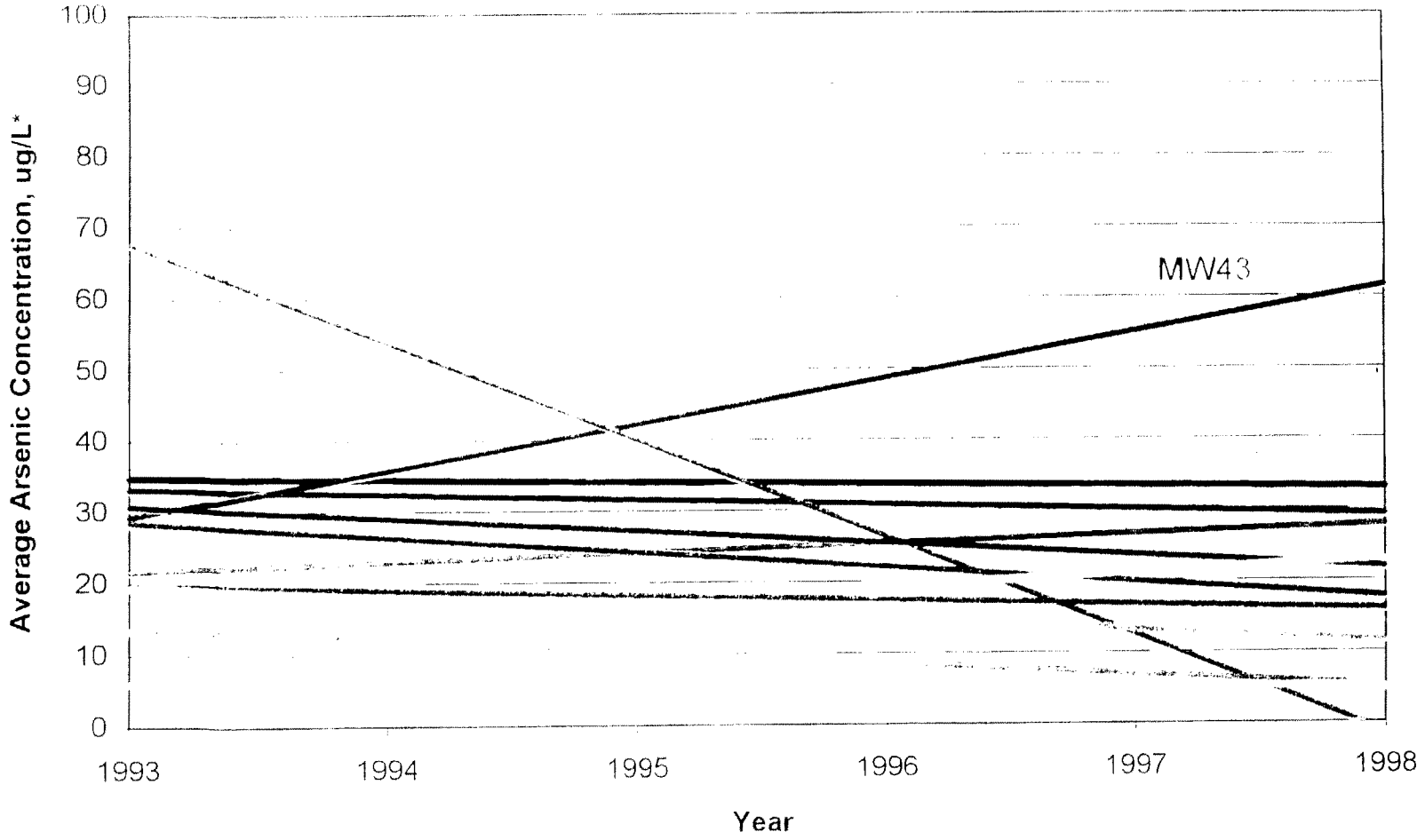


Figure 8. Average Arsenic Concentrations at Different Times for high pH/high pH change Observations

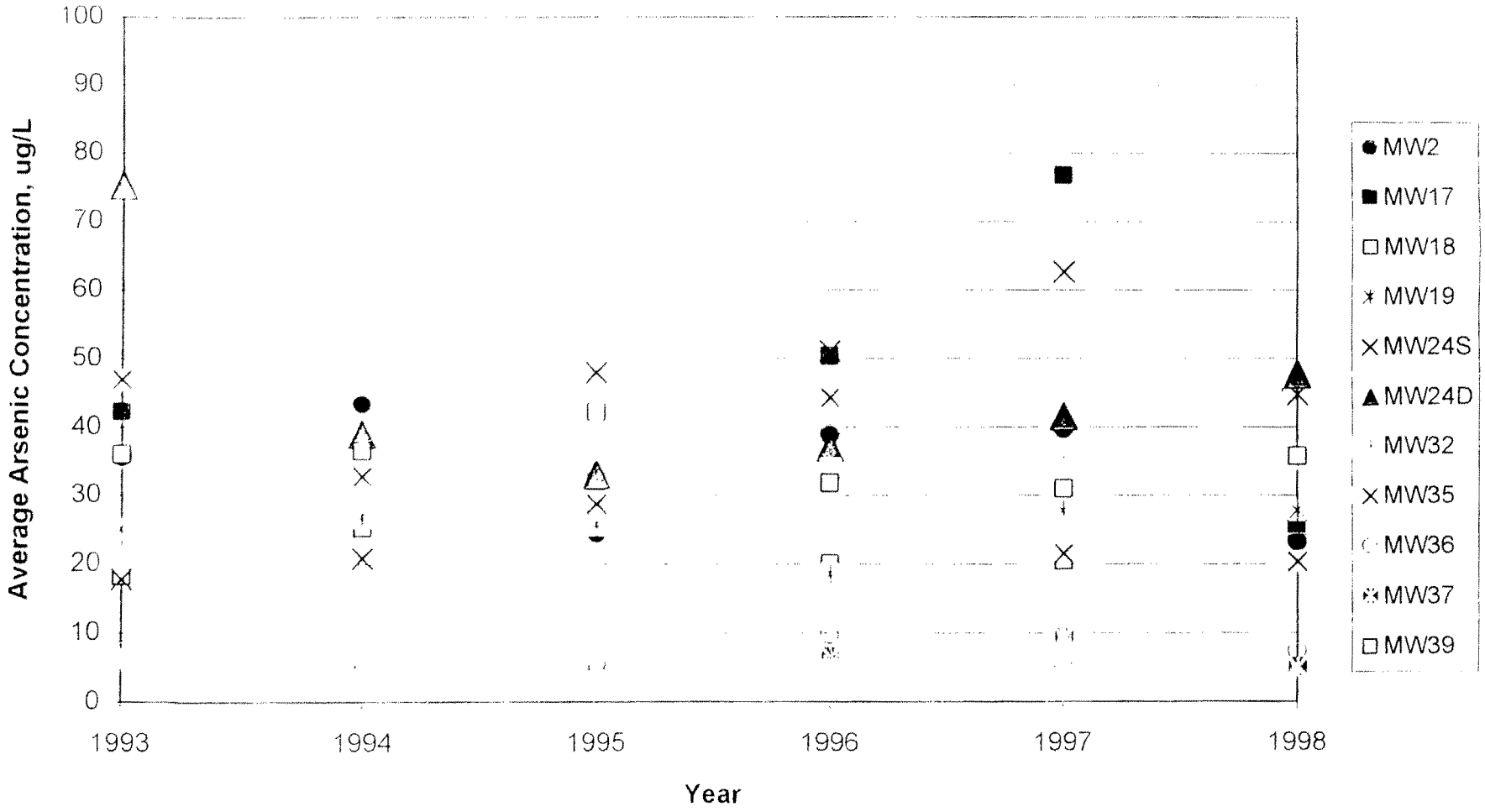
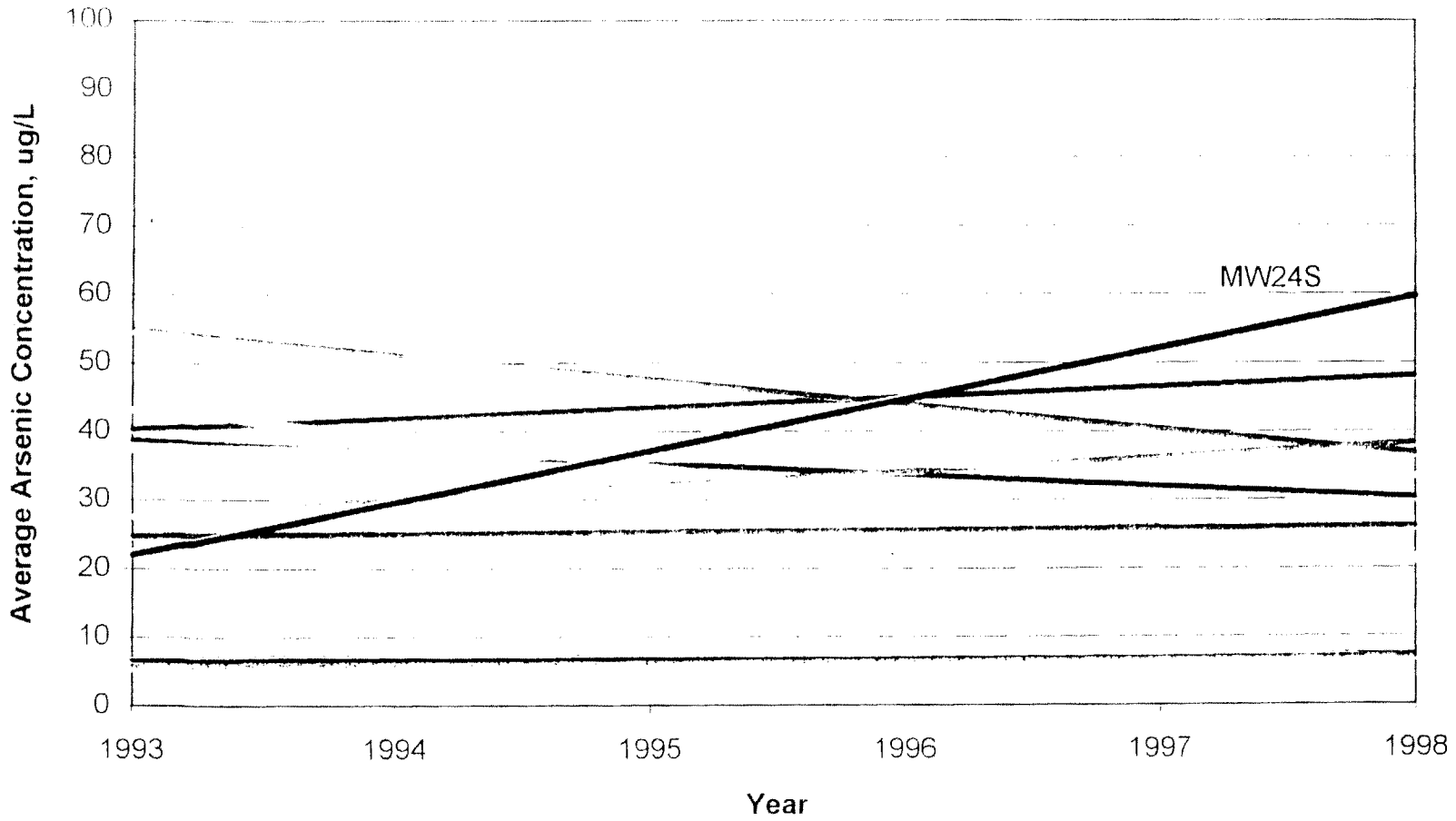


Figure 9. Arsenic Concentration Trend Lines for high pH/high pH Change Observations



There are at least two wells with ground-water quality data that may show trends of increasing arsenic concentrations over time. At present, any such trends are very poorly defined. However, because of the possibility that arsenic concentrations in some areas may be increasing over time, it is recommended to continue quarterly ground-water monitoring of existing site wells with arsenic detections, but also conducting a more comprehensive, statistically-based data evaluation after another year of monitoring data are obtained. Given the potential for arsenic concentration increases due to the increasing ground-water pH, vigilant analysis of the ground-water quality data from this site is advisable.

Attachment E
Site Photos

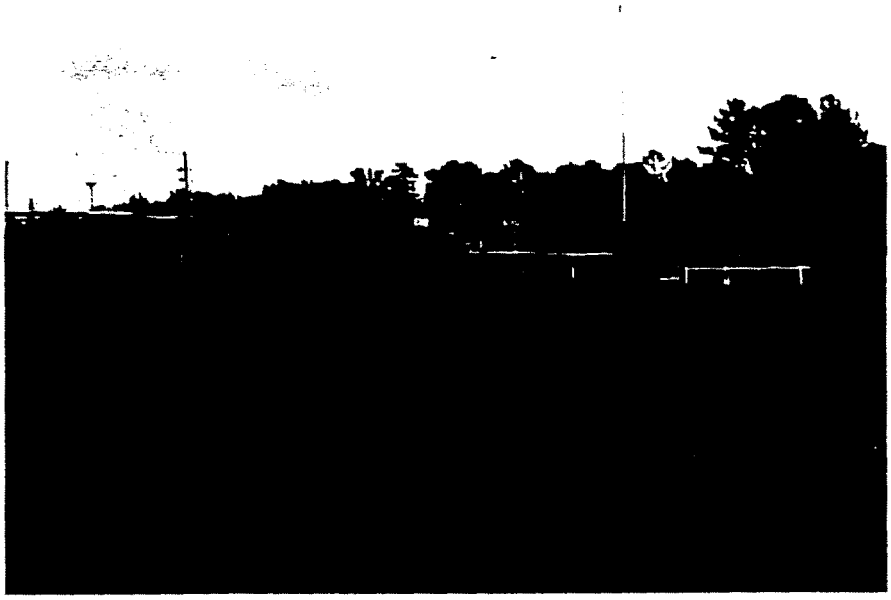


Image 1: 6/29/99 Site View of Landfill #1, facing Southeast from approximately MW10

Image #2: 6/29/99: Site View of the east side of plant from approximate location of MW10, looking north

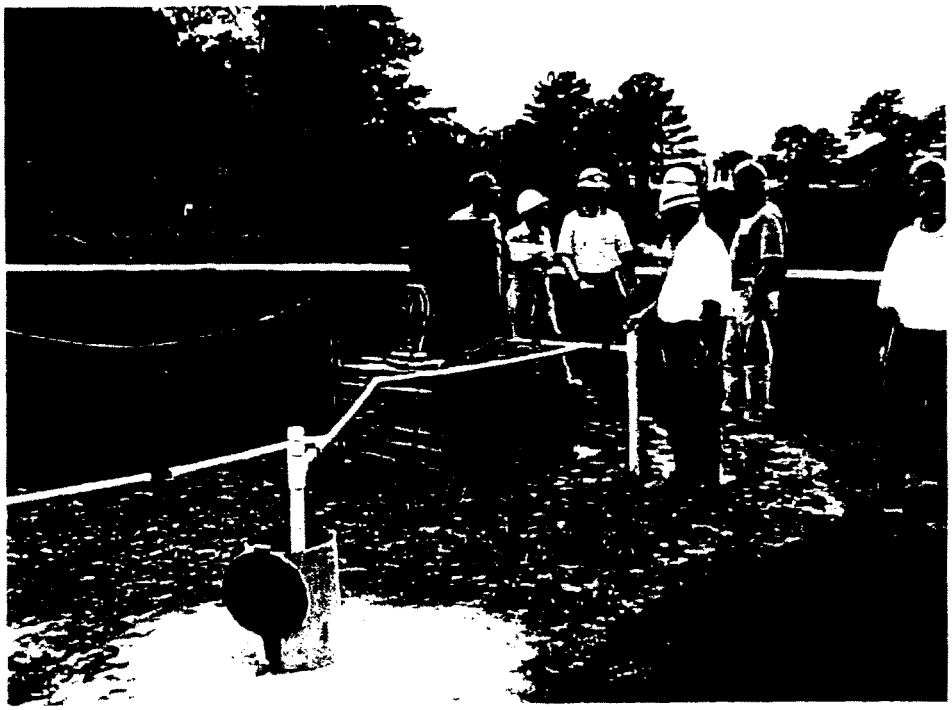


Image #3; 6/29/99; MW at landfill #1.southwestward.

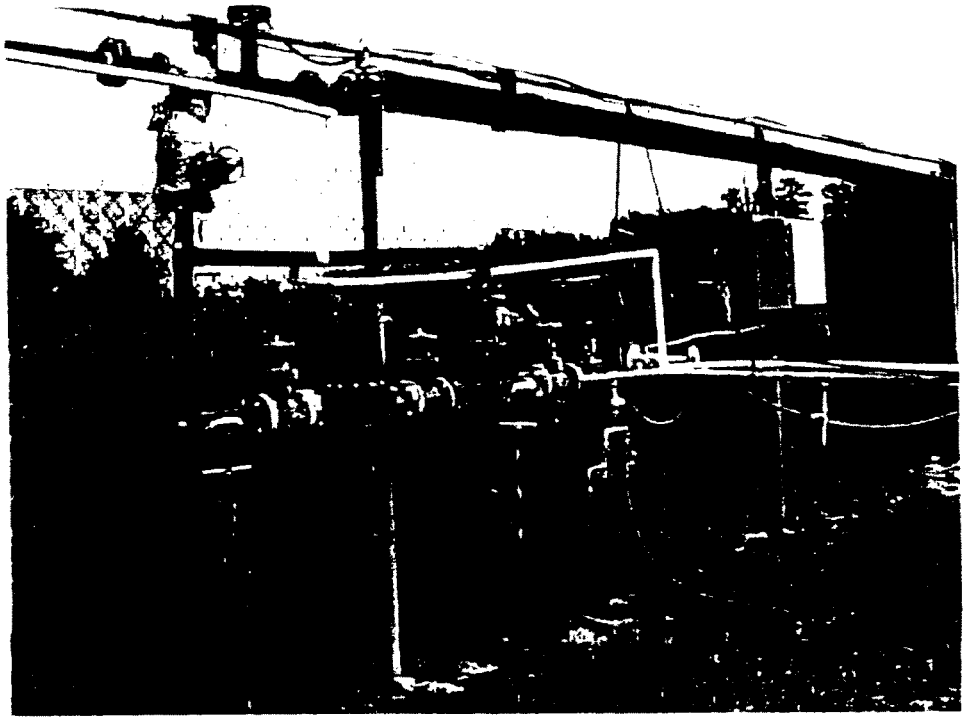


Image #4; 6/29/99; fence area adjacent to Landfill #1;facing southeastward. Manifold system from MW#5

Image #5; 6/29/99; Landfill #2; facing southwestward from approximate location of MW#24S

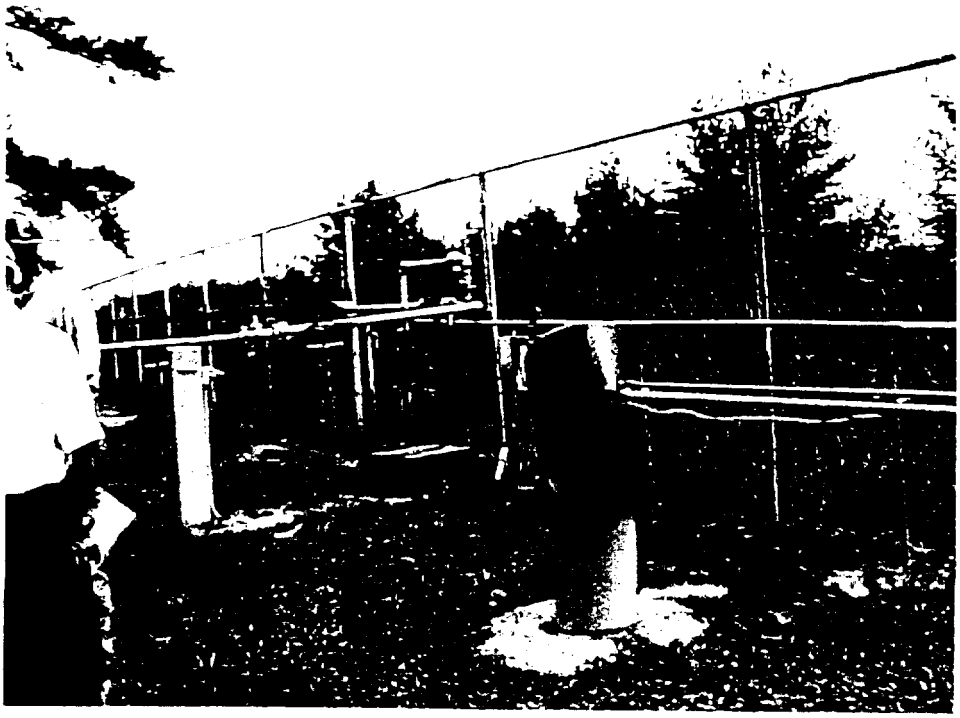


Image #6; 6/29/99; MW#24; facing eastward.